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**A REAL-TIME DIGITAL PROGRAM  
FOR ESTIMATING AIRCRAFT STABILITY  
AND CONTROL PARAMETERS FROM  
FLIGHT TEST DATA BY USING  
THE MAXIMUM LIKELIHOOD METHOD**

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SUMMARY

A computer program (Langley program C1123) has been developed for estimating aircraft stability and control parameters from flight test data. These parameters are estimated by the maximum likelihood estimation procedure implemented on a real-time digital simulation system, which uses the Control Data 6600 computer. This system allows the investigator to interact with the program in order to obtain satisfactory results. Part of this system, the control and display capabilities, is described for this program. This report also describes the computer program by presenting the program variables, subroutines, flow charts, listings, and operational features. Program usage is demonstrated with a test case using pseudo or simulated flight data.

INTRODUCTION

A computer program has been developed at the Langley Research Center to improve the capabilities for estimating aircraft stability and control parameters. Improved capabilities result from the combined utilization of the inherent features of the Langley real-time simulation (RTS) system and the maximum likelihood method. The program has been designed to take advantage of the integrated software and hardware features comprising the RTS system. This system allows the analyst to be an integral part in controlling the direction of the parameter identification study, that is, the analyst communicates or interacts with the program. The analyst interacts with the program by selecting the mathematical model to be used, the variables to be matched with the flight test data, and the parameters to be estimated. The RTS display features aid the analyst in determining whether any further interaction is necessary and when to stop the computer run. The analyst uses the results of the computer run as an aid to solve the problems of correlation, uniqueness, and identifiability of the parameters. Parameter estimation is not a straightforward procedure; thus, having the capability of the analyst interacting with the program is highly desirable.

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\*Electronic Associates, Inc.

The objective of this report is to present the computer program which was written especially for the RTS system at Langley. A description of the system software is beyond the scope of this report; however, the RTS subroutines used are briefly described in order to aid in understanding the flow of the program. The program flow differs from batch programs in that operator action is required. In presenting the program, it becomes necessary to describe the program control station (appendix A) from which the analyst interacts with the program. The maximum likelihood estimation procedure for extracting the stability and control parameters was developed in reference 1.

The program has been dynamically checked by comparing its output with the output of an independently written batch program. Test cases were made by use of simulated flight data with different measurement noise levels to check the estimation procedure. (See ref. 1.) Application of this program is not restricted to the aircraft example being used in this report. The program may be applied to other aircraft as well as other dynamic vehicles satisfying the assumptions of the maximum likelihood estimator. (See ref. 1.) The program developed has been successfully applied to the analysis of flight test data for generically different aircraft. (See refs. 2 to 5.) These reports on the analysis of flight test data also reflect the desirability of analyst program interaction.

## SYMBOLS

Symbols on CalComp plots (figs. 2 and 4) are not standard because of the limitations of the computer.

$A$	sensitivity coefficient matrix
$\vec{a}_I$	accelerometer vector at instrument location
$a_{X,I}, a_{Y,I}, a_{Z,I}$	longitudinal, lateral, and normal (positive down) components of $\vec{a}_I$
$b$	wing span
$C_l, C_m, C_n$	rolling-, pitching-, and yawing-moment coefficients
$(C_l)_{\beta_t, \delta_{a,t}, \delta_{r,t}}$	rolling-moment coefficient at $\beta = \beta_t, \delta_a = \delta_{a,t}, \delta_r = \delta_{r,t}$
$(C_m)_{\alpha_{a,t}, \delta_{e,t}}$	pitching-moment coefficient at $\alpha_a = \alpha_{a,t}, \delta_e = \delta_{e,t}$

$(C_n)_{\beta_t, \delta_{a,t}, \delta_{r,t}}$	yawing-moment coefficient at $\beta = \beta_t, \delta_a = \delta_{a,t}, \delta_r = \delta_{r,t}$
$C_T, C_{T,o}, C_{T_B}$	main-engine thrust coefficients
$C_{T_T}, C_{T_{T_o}}, C_{T_{\beta_T}}$	tail-rotor thrust coefficients
$C_X, C_Y, C_Z$	longitudinal-, lateral-, and normal-force coefficients
$C_{X,o}, C_{Z,o}$	longitudinal-force and normal-force coefficients at $\alpha_a = \delta_e = 0$
$(C_X)_{\alpha_{a,t}, \delta_{e,t}}$	longitudinal-force coefficient at $\alpha_a = \alpha_{a,t}, \delta_e = \delta_{e,t}$
$C_{Y,o}$	lateral-force coefficient at $\beta = \delta_a = \delta_r = 0$
$(C_Y)_{\beta_t, \delta_{a,t}, \delta_{r,t}}$	lateral-force coefficient at $\beta = \beta_t, \delta_a = \delta_{a,t}, \delta_r = \delta_{r,t}$
$(C_Z)_{\alpha_{a,t}, \delta_{e,t}}$	normal-force coefficient at $\alpha_a = \alpha_{a,t}, \delta_e = \delta_{e,t}$
$\bar{c}$	mean aerodynamic chord
$D_E, D_T$	blade diameters of main engine and tail rotor
$\bar{F}$	vector function defined in equations of motion
$F_j$	components of $\bar{F}$ , where $j = 1, 2, \dots, 8$
$G$	sensitivity equation matrix
$g$	acceleration due to gravity
$I_X, I_Y, I_Z$	moment of inertia about X-, Y-, and Z-axis, respectively
$I_{XZ}$	product of inertia
$i, j, k$	integers
$i_w$	wing tilt angle

$J_N$	performance index function
$\bar{l}, r_b, l_{TP}$	coefficients in moment equations
$M_X, M_Y, M_Z$	rolling, pitching, and yawing moments
$m$	mass
$N$	number of data points
$P_E, P_T$	normalized throttle settings of main engine and tail rotor
$p, q, r$	roll, pitch, and yaw angular velocities
$p'$	number of parameters
$R$	measurement noise covariance matrix
$S$	wing area
$T$	flight-test time period
$T_X, T_Y, T_Z$	thrust along X-, Y-, and Z-axis, respectively
$t$	time
$t_i$	data point time, where $i = 1, 2, \dots, N$
$u, v, w$	longitudinal, lateral, and vertical velocity components
$V$	true airspeed
$V_{SS}$	slipstream airspeed
$X, Y, Z$	coordinate axes
$\bar{x}$	state vector
$x_k$	components of $\bar{x}$ , where $k = 1, 2, \dots, 8$

$x_X, y_X, z_X$	center-of-gravity offsets of X-axis accelerometer
$x_Y, y_Y, z_Y$	center-of-gravity offsets of Y-axis accelerometer
$x_Z, y_Z, z_Z$	center-of-gravity offsets of Z-axis accelerometer
$\vec{y}$	variables in performance index function
$\vec{\alpha}$	parameter vector
$\Delta\vec{\alpha}$	parameter change vector
$\alpha_a, \beta$	angles of attack and sideslip
$\alpha_i$	components of $\vec{\alpha}$ , where $i = 1, 2, \dots, 40$
$\beta_T$	tail-rotor blade angle
$\vec{\delta}$	control deflection vector
$\delta_a, \delta_e, \delta_r$	aileron, elevator, and rudder control deflections
$\overline{\delta B}, \overline{\Delta B}$	relationships of blade angles for main engines
$\delta_{ik}$	Kronecker delta
$\vec{\eta}$	measurement noise vector
$\eta_E, \eta_T$	main-engine and tail-rotor speeds
$\eta_i$	components of $\vec{\eta}$ , where $i = 1, 2, \dots, 11$
$\rho$	atmospheric density
$\rho_{\alpha_i \alpha_j}$	correlation coefficient of $\alpha_i$ and $\alpha_j$
$\sigma_{\alpha_i}^2, \sigma_{\alpha_i}$	variance and standard deviation of $\alpha_i$

$\sigma_{\eta_i \eta_j}$ covariance of  $\eta_i$  and  $\eta_j$  $\phi, \theta, \psi$ 

roll, pitch, and yaw angles

Stability and control derivatives:

$$C_{Xq} = \frac{\partial C_X}{\partial \frac{q\bar{c}}{2V}}$$

$$C_{Yp} = \frac{\partial C_Y}{\partial \frac{pb}{2V}}$$

$$C_{Zq} = \frac{\partial C_Z}{\partial \frac{q\bar{c}}{2V}}$$

$$C_{X\alpha_a} = \frac{\partial C_X}{\partial \alpha_a}$$

$$C_{Yr} = \frac{\partial C_Y}{\partial \frac{rb}{2V}}$$

$$C_{Z\alpha_a} = \frac{\partial C_Z}{\partial \alpha_a}$$

$$C_{lp} = \frac{\partial C_l}{\partial \frac{pb}{2V}}$$

$$C_{Y\beta} = \frac{\partial C_Y}{\partial \beta}$$

$$C_{Z\delta_e} = \frac{\partial C_Z}{\partial \delta_e}$$

$$C_{lr} = \frac{\partial C_l}{\partial \frac{rb}{2V}}$$

$$C_{Y\dot{\beta}} = \frac{\partial C_Y}{\partial \frac{\dot{\beta}b}{2V}}$$

$$C_{np} = \frac{\partial C_n}{\partial \frac{pb}{2V}}$$

$$C_{l\beta} = \frac{\partial C_l}{\partial \beta}$$

$$C_{Y\delta_r} = \frac{\partial C_Y}{\partial \delta_r}$$

$$C_{nr} = \frac{\partial C_n}{\partial \frac{rb}{2V}}$$

$$C_{l\dot{\beta}} = \frac{\partial C_l}{\partial \frac{\dot{\beta}b}{2V}}$$

$$C_{mq} = \frac{\partial C_m}{\partial \frac{q\bar{c}}{2V}}$$

$$C_{n\beta} = \frac{\partial C_n}{\partial \beta}$$

$$C_{l\delta_a} = \frac{\partial C_l}{\partial \delta_a}$$

$$C_{m\alpha_a} = \frac{\partial C_m}{\partial \alpha_a}$$

$$C_{n\dot{\beta}} = \frac{\partial C_n}{\partial \frac{\dot{\beta}b}{2V}}$$

$$C_{l\delta_r} = \frac{\partial C_l}{\partial \delta_r}$$

$$C_{m\dot{\alpha}_a} = \frac{\partial C_m}{\partial \frac{\dot{\alpha}_a \bar{c}}{2V}}$$

$$C_{n\delta_a} = \frac{\partial C_n}{\partial \delta_a}$$

$$C_{m\delta_e} = \frac{\partial C_m}{\partial \delta_e}$$

$$C_{n\delta_r} = \frac{\partial C_n}{\partial \delta_r}$$

### Superscripts:

-1	inverse matrix operation
M	measured value
o	nominal evaluation
T	transpose matrix operation

### Subscripts:

eq	active variables in $\bar{x}$
J	active variables in $\bar{y}$
t	trim condition

Dot over a symbol denotes time derivative. Arrow over symbol denotes vector.  
|R| denotes determinant of R.

## PROBLEM DESCRIPTION

The stability and control parameters are the unknown coefficients in the differential equations of motion of the aircraft. The maximum likelihood estimation procedure, using the method of quasilinearization, estimates the stability and control parameters by minimizing the difference between the flight test measurements and the calculated solution of the differential equations of motion of the aircraft.

The measured control deflections of the aircraft are used as inputs to the equations of motion, and the flight test measurements are assumed to be the true solution with measurement noise (Gaussian with zero mean). The initial conditions of the state are included as unknown parameters and the accelerometer equations supplement the equations of motion in the estimation procedure.

### Aircraft Mathematical Model

The detailed nonlinear aircraft mathematical model is described in appendix B, where the equations of motion are represented in vector notation by

$$\dot{\bar{x}} = \bar{F}(\bar{x}, \bar{\alpha}, \bar{\delta}, V, \alpha_a, \dot{\alpha}_a, \beta, \dot{\beta}) \quad (1)$$

For simplicity in describing the estimation procedure, let the equations of motion be written as

$$\dot{\vec{x}} = \vec{F}(\vec{x}, \vec{\alpha}, \vec{\delta}) \quad (1a)$$

where the terms omitted in equation (1a) are auxiliary relationships. The equation variables (states) are

$$\vec{x}(\vec{\alpha}, t) = [u, v, w, p, q, r, \theta, \phi]^T \quad (2)$$

The parameter vector is

$$\vec{\alpha} = [\alpha_1, \alpha_2, \dots, \alpha_{p'}]^T \quad (3)$$

The control inputs are

$$\vec{\delta} = [\delta_a, \delta_e, \delta_r]^T = \vec{\delta}^M \quad (4)$$

Integration of the equations of motion yields the nominal solution  $\vec{x}(\vec{\alpha}^0, t)$ , where  $\vec{\alpha}^0$  is the nominal or current value of the parameter vector. These parameters are the aerodynamic coefficients (stability and control parameters) and the initial conditions of the states. The initial values of the coefficients are determined from a prior estimate (wind-tunnel data or analysis) and the initial states are determined from the flight test data.

The accelerometer equations

$$\vec{a}_I = (a_{X,I}, a_{Y,I}, a_{Z,I})^T \quad (5)$$

are algebraic functions of the states and their derivatives. These equations need only to be evaluated and not integrated.

### Sensitivity Equations

The sensitivity equations are derived by formally differentiating the equations of motion with respect to each parameter. (See ref. 1.) The sensitivity equations are (by using eq. (1a))

$$\frac{d}{dt} \left( \frac{\partial \vec{x}}{\partial \alpha_i} \right) = \sum_{k=1}^8 \frac{\partial \vec{F}}{\partial x_k} \left( \frac{\partial x_k}{\partial \alpha_i} \right) + \frac{\partial \vec{F}}{\partial \alpha_i} = G(t) \left( \frac{\partial \vec{x}}{\partial \alpha_i} \right) + \frac{\partial \vec{F}}{\partial \alpha_i} \quad (i = 1, 2, \dots, p') \quad (6)$$

This system of equations represents  $p'$  sets of eight simultaneous differential equations. Integration yields the sensitivity coefficients  $\partial x_k / \partial \alpha_i$ . All the initial conditions are zero except for

$$\left. \frac{\partial x_k}{\partial \alpha_i} \right|_{t=0} = \left. \frac{\partial x_k}{\partial x_i(0)} \right|_{t=0} = \delta_{ik}$$

The accelerometer sensitivity coefficients  $\partial \bar{a}_I / \partial \alpha_i$  are functions of the sensitivity equations and coefficients previously defined. The sensitivity equations and accelerometer sensitivity coefficients are presented in detail in appendix C.

### Maximum Likelihood Estimation Equations

The maximum likelihood estimation equations (using quasilinearization) are derived from the likelihood function in reference 1. The maximum likelihood parameter estimation procedure (the accelerometer equations being neglected) is diagrammed in figure 1. The estimation procedure is initially formulated by using the complete mathematical model; then, by using variable dimensioning (appendix D), it is reduced to the specific flight test case being analyzed.

The parameter-change equations are

$$\Delta \bar{\alpha} = \left[ \sum_{i=1}^N A^T(t_i) R^{-1} A(t_i) \right]^{-1} \left[ \sum_{i=1}^N A^T(t_i) R^{-1} \bar{\eta}(t_i) \right] \quad (7)$$

where

$$A(t_i) = \left( \frac{\partial \bar{y}^0}{\partial \alpha_1}, \frac{\partial \bar{y}^0}{\partial \alpha_2}, \dots, \frac{\partial \bar{y}^0}{\partial \alpha_{p'}} \right)$$

$$\bar{\eta}(t_i) = \bar{y}^M(t_i) - \bar{y}^0(t_i)$$

$$\bar{y}^M(t_i) = \begin{bmatrix} \bar{x}^M(t_i) \\ \bar{a}_I^M(t_i) \end{bmatrix} \quad \bar{y}^0(t_i) = \begin{bmatrix} \bar{x}^0(t_i) \\ \bar{a}_I^0(t_i) \end{bmatrix}$$

Here  $\bar{y}^0$  denotes the variables in the performance index function.

The covariance matrix for the parameters is

$$\left[ \sum_{i=1}^N A^T(t_i) R^{-1} A(t_i) \right]^{-1}$$

The covariance matrix for the measurement noise is

$$R^0(N) \triangleq \text{Estimate of } R = \frac{1}{N} \sum_{i=1}^N \tilde{\eta}(t_i) \tilde{\eta}^T(t_i)$$

and the performance index function to be minimized is

$$J_N(\tilde{\alpha}^0) = |R^0(N)| \quad (9)$$

The flight test data are composed of the onboard instrument measurements of the aircraft behavior and are assumed to be the output of the aircraft mathematical model superimposed with instrument noise. These data contain many individual aircraft maneuvers stored on one magnetic tape, each maneuver being easily accessible to the central memory of the computer. These data are used for comparison with the mathematical model output and for initialization of and control input to the equations of motion. The measurements  $\tilde{y}^M(t_i)$  and  $\tilde{\delta}^M(t_i)$  for  $i = 1, 2, \dots, N$  are known for all performance index variables and control deflections corresponding to the aircraft mathematical model.

The steps in the maximum likelihood estimation procedure, corresponding to figure 1, are as follows:

- (1) Initialize the system parameters where  $\tilde{\alpha}^0$  denotes the nominal or current values of the parameters.
- (2) Integrate the equations of motion and the sensitivity equations to obtain the nominal solution and the sensitivity coefficient matrix, respectively.
- (3) Calculate the comparisons of the flight test data and nominal solution for each data point time at  $t_i$  where  $i = 1, 2, \dots, N$  and  $t_1 = 0$  and  $t_N = T$ .
- (4) Calculate the maximum likelihood estimation equations from the comparisons in step (3) and the sensitivity coefficient matrix in step (2). (Dashed lines in fig. 1 indicate accumulation of information over the flight test time period  $T$ .)
- (5) Calculate the performance index  $J_N(\tilde{\alpha}^0)$ .
- (6) Calculate the parameter changes  $\Delta\tilde{\alpha}$  and the statistical information matrix  $R^0(N)$ .

(7) Update the nominal parameter values in step (1) to start the next iteration procedure and repeat steps until convergence. Convergence of the estimation procedure is assumed when the change in the performance index is small enough to satisfy the criterion of the analyst.

## PROGRAM DESCRIPTION

### Labeled COMMON

The following list contains the FORTRAN variables appearing in labeled COMMON and descriptions of each variable:

<u>COMMON label</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
/INTCOMM/	T	t, updated in subroutine IGRATE1
	H	Integration step size used in subroutine IGRATE1 (H = DT)
	INT	Flow control parameter used in subroutine IGRATE1
	NEQ	Number of integrations performed in subroutine IGRATE1, $NEQ \leq 249$
	ISCHEME	Selects integration scheme in subroutine IGRATE1
	DERINT(2,249)	Array of integrals and derivatives in subroutine IGRATE1
/INTINTR/	INTERN(5,249)	Temporary storage array for subroutine IGRATE1
/REALTIM/	ADC(32)	Analog-to-digital converter input array
	DAC(64)	Digital-to-analog converter output array
	LDISI(108)	Logical discrete input array

<u>COMMON label</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
/REALTIM/	LDISO(196)	Logical discrete output array
	NOPER	Return addresses from subroutine RTMODE
	NHOLD	
	NRESET	
	NTERM	
	NPRINT	
	NREAD	
	Not used with subroutine PCCEXEC	
/ALGOR/	NPAR	Total number of parameters
	IPAR	Maximum number of active parameters
	INTP(30)	Array denoting active parameters
	IP	Number of active parameters
	INTV(8)	Array denoting active equation variables
	IV	Number of active equation variables
	INTA(11)	Array denoting active performance index variables
	IA	Number of active performance index variables
	IA1	Number of active equation variables which are active performance index variables
IA2	IA-IA1	

<u>COMMON label</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
/ALGOR/	PARAM(40)	Arrays of labels for printout
	DPARAM(30)	
	ALV(11)	
	DVAR(8)	
	DALG(11)	
	ALG(40)	Auxiliary storage array for AL
	IAC(40)	Auxiliary storage array for INTEG(I) (I = 1, 2, . . . , 40)
	IEVEN	Used with LOGIC(11)
	WT(11,11)	$R_J^{0-1}(N)$
	COM	Labels for printout
	L1	
	L2	
/COMM1/	IRR	Error condition set by subroutine NAMECRT
	IPL	Overlay level numbers used by subroutine PCCEXEC
	ISL	
	TABLE(199)	Array of floating-point numbers to be displayed and/or changed
	INTEG(99)	Array of integer numbers to be displayed and/or changed

<u>COMMON label</u>	<u>FORTRAN variable(s)</u>	<u>Description</u>
/COMM1/	LOGIC(20)	Logical array for selecting program options
	NTAB	Dimensions used by subroutines DATBLX and INOUT
	NINT	
	NLOG	
	NADC	
	NDAC	
	NLDI	
	NLDO	
	NT	Recording frequency for real-time disk file
	AXI	$a_{X,I}$
	AYI	$a_{Y,I}$
	AZI	$a_{Z,I}$
	DRAD	57.2958
	RADD	$(DRAD)^{-1}$
	PI	3.141593
	IR(2)	Array of integers used by subroutine GETRAN
	NRN	Number of random number sequences
	NPTS	Maximum number of data points

<u>COMMON label</u>	<u>FORTRAN variable(s)</u>	<u>Description</u>
/COMM1/	ISKIP	} Skips initialization statements
	JSKIP	
	KSKIP	
	MF	Output disk file
	TX	$T_X$
	TY	$T_Y$
	TZ	$T_Z$
	AMX	$M_X$
	AMY	$M_Y$
	AMZ	$M_Z$
	VARCHNG	Flag set by subroutine DSPLAY
	ITYPE	Data format set by subroutine DSPLAY
	IVARBUF(5)	Buffer used by subroutine DSPLAY
	DELX	Flight data time interval used in program (INC · TT)
	NOITSPS	Integration steps per flight data time interval $\frac{DELX}{DT}$
	PTSINV	$(N)^{-1}$
/COMM2/	MAXPAGE	CRT memory allotment

<u>COMMON label</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
/COMM2/	LABT	Axis labels for plotting
	LABU	
	LABV	
	LABW	
	LABP	
	LABQ	
	LABR	
	LABTH	
	LABPH	
	LABAX	
	LABAY	
	LABAZ	
	LABDA	
	LABDE	
	LABDR	
	FET25(17)	Array containing file environment table for flight data file (TAPE25)
	LUN25	Logical unit number for TAPE25
	NAM25	Name of file TAPE25 used in subroutine CREATEF

<u>COMMON label</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
/COMM2/	ITRNMLT(7)	Arrays of matrix operation and dimension information used by subroutine MASCNT
	IMULTA(7)	
	INVSEN(7)	
	IMULTB(7)	
	INVWT(7)	
/FLIGHT/	UM(201)	$u^M(t_i)$
	VM(201)	$v^M(t_i)$
	WM(201)	$w^M(t_i)$
	PM(201)	$p^M(t_i)$
	QM(201)	$q^M(t_i)$
	RM(201)	$r^M(t_i)$
	THM(201)	$\theta^M(t_i)$
	PHM(201)	$\phi^M(t_i)$
	AXM(201)	$a_{X,I}^M(t_i)$
	AYM(201)	$a_{Y,I}^M(t_i)$
	AZM(201)	$a_{Z,I}^M(t_i)$
	FDA(201)	$\delta_a^M(t_i)$
	FDE(201)	$\delta_e^M(t_i)$
	FDR(201)	$\delta_r^M(t_i)$

<u>COMMON label</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
/FLIGHT/	FBT(201)	$\beta_T(t_i)$
	FDB(201)	$\overline{\delta B}(t_i)$
	FDELB(201)	$\overline{\Delta B}(t_i)$
	FPPER(201)	$P_E(t_i)$
	FTPER(201)	$P_T(t_i)$
	BETAT	$\beta_T$
	ETA	$\eta_E$
	ETAT	$\eta_T$
	FCT(12)	Array containing function for $C_T \beta_T \beta_T$
	CTT	$C_{TT}$
	CT	$C_T$

#### Display Arrays

The real-time simulation program uses specified arrays (subroutine DSPLAY arrays) for displaying and/or changing the value of desired program variables. (See appendix A.) The desired program variables as defined in these specified arrays are assigned display addresses as shown in the following table:

Subroutine DSPLAY arrays	Display address	Maximum number of elements
TABLE(I)	I	199
INTEG(I)	I + 200	99
LOGIC(I)	I + 300	99
ADC(I) (not used)	I + 400	99
DAC(I)	I + 500	99
LDISI(I)	I + 600	99
LDISO(I)	I + 700	199

This type of addressing is called "IN TABLES" addressing. For program variables not in subroutine DSPLAY arrays, a type of addressing called "NO TABLES" addressing is used.

Subroutine DSPLAY arrays are listed below with their associated FORTRAN variables and descriptions (elements not mentioned are not used). The array elements are equivalenced to the FORTRAN variables, except where equality signs indicate. TABLE is a floating-point number array, and equivalence between FORTRAN variables is indicated by a semicolon.

<u>TABLE element(s)</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
1	AL(1);UO	$u(0)$
2	AL(2);CXO	$(CX)_{\alpha_a, t, \delta_e, t}$
3	AL(3);CXAL	$CX_{\alpha_a}$
4	AL(4);CXQ	$CX_q$
5	AL(5);THEO	$\theta(0)$
6	AL(6);PHIO	$\phi(0)$
7	AL(7);WO	$w(0)$
8	AL(8);CZO	$(CZ)_{\alpha_a, t, \delta_e, t}$
9	AL(9);CZAL	$CZ_{\alpha_a}$
10	AL(10); CZQ	$CZ_q$
11	AL(11);CZDE	$CZ_{\delta_e}$
12	AL(12);QO	$q(0)$
13	AL(13);CMO	$(Cm)_{\alpha_a, t, \delta_e, t}$

<u>TABLE element(s)</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
14	AL(14);CMAL	$C_{m\alpha_a}$
15	AL(15);CMALD	$C_{m\dot{\alpha}_a}$
16	AL(16);CMQ	$C_{mq}$
17	AL(17);CMDE	$C_{m\delta_e}$
18	AL(18);VO	$v(0)$
19	AL(19);CYO	$(C_Y)_{\beta_t, \delta_{a,t}, \delta_{r,t}}$
20	AL(20);CYB	$C_{Y\beta}$
21	AL(21);CYBD	$C_{Y\dot{\beta}}$
22	AL(22);CYP	$C_{Yp}$
23	AL(23);CYR	$C_{Yr}$
24	AL(24);CYDR	$C_{Y\delta_r}$
25	AL(25);PO	$p(0)$
26	AL(26);CLO	$(C_l)_{\beta_t, \delta_{a,t}, \delta_{r,t}}$
27	AL(27);CLB	$C_{l\beta}$
28	AL(28);CLBD	$C_{l\dot{\beta}}$
29	AL(29);CLP	$C_{lp}$
30	AL(30);CLR	$C_{lr}$

<u>TABLE element(s)</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
31	AL(31);CLDR	$Cl_{\delta_r}$
32	AL(32);CLDA	$Cl_{\delta_a}$
33	AL(33);RO	$r(0)$
34	AL(34);CNO	$(C_n)_{\beta_t, \delta_a, t, \delta_r, t}$
35	AL(35);CNB	$C_{n\beta}$
36	AL(36);CNBD	$C_{n\dot{\beta}}$
37	AL(37);CNP	$C_{np}$
38	AL(38);CNR	$C_{nr}$
39	AL(39);CNDR	$C_{n\delta_r}$
40	AL(40);CNDA	$C_{n\delta_a}$
50	UMAX	CalComp, CRT, and DAC scaling information
51	VMAX	
52	WMAX	
53	PMAX	
54	QMAX	
55	RMAX	
56	THMAX	
57	PHMAX	
58	AXMAX	

<u>TABLE element(s)</u>	<u>FORTRAN variable(s)</u>	<u>Description</u>
59	AYMAX	CalComp, CRT, and DAC scaling information
60	AZMAX	
62	DAMAX	
63	DEMAX	
64	DRMAX	
65	UMULT	Flight test data multipliers
66	VMULT	
67	WMULT	
68	PMULT	
69	QMULT	
70	RMULT	
71	THMULT	
72	PHMULT	
73	AXMULT	
74	AYMULT	
75	AZMULT	
76	DAMULT	
77	DEMULT	
78	DRMULT	

<u>TABLE element(s)</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
79	UBIAS	Flight test data biases
80	VBIAS	
81	WBIAS	
82	PBIAS	
83	QBIAS	
84	RBIAS	
85	THBIAS	
86	PHBIAS	
87	AXBIAS	
88	AYBIAS	
89	AZBIAS	
90	DABIAS	$\delta_{a,t}$
91	DEBIAS	$\delta_{e,t}$
92	DRBIAS	$\delta_{r,t}$
98	RUN	Run number
99	PASS	Iteration number
100	AJP	$\sum_{i=1}^N \eta_J^T(t_i) \eta_J(t_i)$
101-104	DRM(4)	Array of desired random means

<u>TABLE element(s)</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
117	AIX	$I_X$
118	AIY	$I_Y$
119	AIZ	$I_Z$
120	AIXZ	$I_{XZ}$
121	WEIGHT	Weight of aircraft (mg)
122	GRAV	$g$
123	RHO	$\rho$
124	S	S
125	B	$b$
126	CBAR	$\bar{c}$
127	DEAMPL	Amplitude of $\delta_e$ for test case
128	DEFREQ	Frequency of $\delta_e$ for test case
129	ALPHAT	$\alpha_{a,t}$
130	DT	Integration step size ( $H = DT$ )
131	TT	Time interval for flight test data tape
132	TS	Tape starting time for putting in flight data
133	TIMF	Final time for CRT display
134	=T	$t$
135	=U	$u$

<u>TABLE element(s)</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
136	=V	$v$
137	=W	$w$
138	=P	$p$
139	=Q	$q$
140	=R	$r$
141	=THE	$\theta$
142	=PHI	$\phi$
143	=PSI	$\psi$
144	=UDOT	$\dot{u}$
145	=VDOT	$\dot{v}$
146	=WDOT	$\dot{w}$
147	=PDOT	$\dot{p}$
148	=QDOT	$\dot{q}$
149	=RDOT	$\dot{r}$
150	=THEDOT	$\dot{\theta}$
151	=PHIDOT	$\dot{\phi}$
152	=PSIDOT	$\dot{\psi}$
154	XX	$x_X$

<u>TABLE element(s)</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
155	YX	$y_X$
156	ZX	$z_X$
157	XY	$x_Y$
158	YY	$y_Y$
159	ZY	$z_Y$
160	XZ	$x_Z$
161	YZ	$y_Z$
162	ZZ	$z_Z$
169	CMCON	Constant used with LOGIC(6)
170	DALMLT	Parameter step size multiplier
171	UCRTBI	u bias for CalComp, CRT, and DAC presentations
172	AIW	$i_w$
173	CTO	$C_{T,o}$
174	CTTO	$C_{T,T_0}$
175	CTB	$C_{TB}$
176	CTBT	$C_{T\beta_T}$
177	D	$D_E$
178	CAPDT	$D_T$

<u>TABLE element(s)</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
179	ELBAR	$\bar{l}$
180	ELTP	$l_{TP}$
181	RB	$r_b$
182	PPER	$P_E$
183	TPER	$P_T$
184	BTBIAS	Flight test data biases
185	PPERBI	
186	TPERBI	
187	DET1	Inverse determinant of parameter covariance matrix
188	DET2	$ R_J^0(N) $
191-194	DRSD(4)	Array of desired standard deviations of random numbers

INTEG is an integer number array.

<u>INTEG element(s)</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
1-40		Array denoting activeness of parameters
51-61	INTY(11)	Array denoting activeness of performance index variables
62	NOPTS	N
63	INC	Sample rate for flight data tape

<u>INTEG element(s)</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
64	IPRINT	Selects options in overlay level (2,0)
65	NPLOT	Density of plotting symbols for CalComp plots
66	IREAD	Selects options in overlay level (3,0)
67	KSCAN	Scan rate, used by subroutine SCANNER
81-88	INTX(8)	Array denoting activeness of equation variables

LOGIC is a logical array and the descriptions are for a true (.T.) value.

<u>LOGIC element(s)</u>	<u>Description</u>
1	Calculate $R_J^{O-1}(N)$
2	Diagonalize $R_J^O(N)$
3	Set $P_E = FPPER(1)$
4	Set $P_T = FTPER(1)$
5	Calculate $C_{T\beta_T} \beta_T$ from FCT(12) and $\beta_T$
6	Set $C_{Z\delta_e} = CMCON \cdot C_{m\delta_e}$
7	Set longitudinal states equal to flight test data
8	Set $\alpha_{a,t} = \tan^{-1} \frac{w(0)}{u(0)}$
9	Calculate parameters to trim $\dot{\bar{x}}$ to zero
10	Automate LOGIC(9)
11	Automate two-pass updating

DAC is an output array for the time history recorder.

<u>DAC element(s)</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
1	$= (U - UCRTBI) / UMAX$	Normalized time history recordings
2	$= V / VMAX$	
3	$= W / WMAX$	
4	$= P / PMAX$	
5	$= Q / QMAX$	
6	$= R / RMAX$	
7	$= THE / THMAX$	
8	$= PHI / PHMAX$	

LDISI is a logical discrete input array where the descriptions are for true (.T.) values of the switches.

<u>LDISI element(s)</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
1-16		Data entry keyboard
17		OPERATE (OPER) mode switch
18		HOLD mode switch
19		RESET mode switch
20		TERMINATE (TERM) mode switch
21		CHANGE mode switch
22		SCAN mode switch

<u>LDISI element(s)</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
23		RELEASE mode switch, releases CHANGE or SCAN mode switch
27		ERASE mode switch
29		IDLE mode switch
30		PRINT mode switch
31		READ mode switch
32		RELEASE mode switch, releases ERASE, IDLE, PRINT, or READ mode switch
33	FSS(1)	Accelerometer variables for CRT display and CalComp plot
34	FSS(2)	CalComp plot of flight data only
35	FSS(3)	Fill flight data arrays with pseudo data
36	FSS(4)	Initialize variable dimensioning
37	FSS(5)	Iteration printout on MF file
39	FSS(7)	Lateral variables for CRT display and CalComp plot
40	FSS(8)	Control variables for CRT display and CalComp plot
41	FSS(9)	Pseudo flight controls
42	FSS(10)	Skip update of $\vec{\alpha}^0$
43	FSS(11)	Activates typewriter for subroutine DISPLAY

<u>LDISI element(s)</u>	<u>FORTTRAN variable(s)</u>	<u>Description</u>
44	FSS(12)	Retain $\bar{x}(0)$ in ALG array
45	FSS(13)	Exit CRT or CalComp loop
46	FSS(14)	Replot the CRT or CalComp plot
47	FSS(15)	Enter CRT loop
48	FSS(16)	"IN TABLES" addressing (false (.F.) for "NO TABLES" addressing)

LDISO is a logical discrete output array used to turn the white indicator lights (WL) on (.T.) and off (.F.). The diagnostics are given for .T. value.

<u>LDISO element</u>	<u>FORTTRAN variable(s)</u>	<u>Diagnostic</u>
61	WL(1)	Default value used for IPRINT
62	WL(2)	CalComp plot completed
63	WL(3)	Error in CalComp plot loop
66	WL(6)	Default value used for IREAD
67	WL(7)	Attempted to read flight data beyond end of file
70	WL(10)	$N > NPTS$
71	WL(11)	$IP > IPAR$
72	WL(12)	Inactive equation variable in performance index
73	WL(13)	$ \theta  > 1.5$

<u>LDISO element(s)</u>	<u>FORTTRAN variable(s)</u>	<u>Diagnostic</u>
74	WL(14)	$u < 5$
75	WL(15)	$ v  \geq u$
76	WL(16)	$ \alpha_a  > 1.5$
77	WL(17)	Invalid flight data location used
78	WL(18)	DET1 = 0
79	WL(19)	DET2 = 0
80	WL(20)	In CRT loop

#### Subroutine Descriptions

The following are the subroutines used and brief statements describing their functions.

<u>Subroutine</u>	<u>Description</u>
ASCALE	Determines origin and scale factor of time axis for CalComp plots
ATERM	Does final processing and halts execution
AXES	Draws and annotates axes for CalComp plots
CALPLT	Moves plotter pen to new location or signals end of CalComp job
CLRPLT	Clears the CRT plot of the calculated variables
CLRTABL	Clears existing plot parameter tables for CRT variables
CREATEF	Creates disk file for flight data tape
CRTPLOT	Establishes plot parameters for CRT variables and/or generates annotated plotting grids

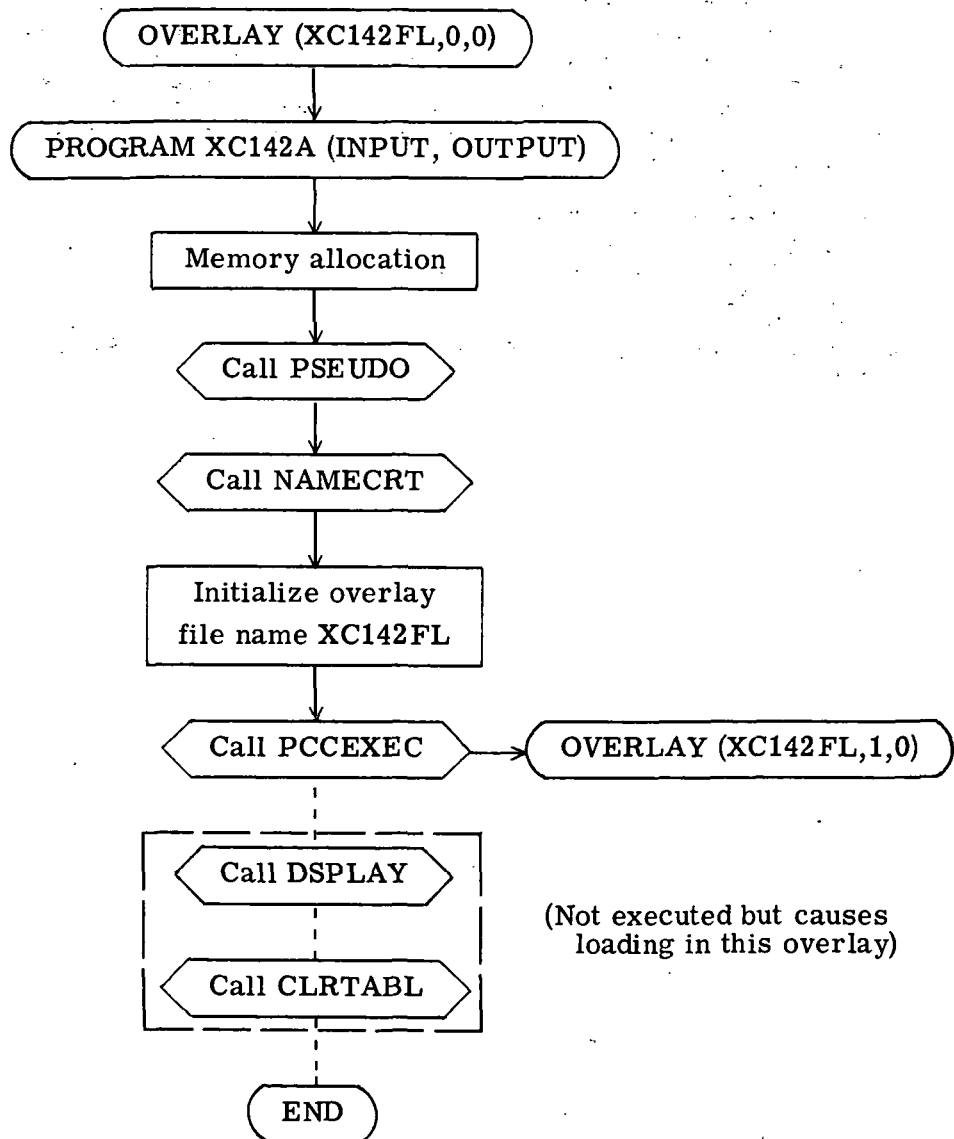
<u>Subroutine</u>	<u>Description</u>
CYCLE	Sets up return address for subroutine RECYCLE
DATABLX	Specifies the variable arrays for subroutine DSPLAY
DAYTIM	Provides date and time of day
DSPLAY	Activates data entry keyboard and digital decimal display unit
ENDPLOT	Marks an end to the CRT plot
ERASE	Erases data on real-time disk file
GETRAN	Generates Gaussian random numbers
GRID	Draws grid for CalComp plots
HALT	Signals completion of real-time portion of program
IGRATE1	Integrates variables in DERINT(2,J) and stores results in DERINT(1,J) (J = 1, 2, . . . , NEQ)
INOUT	Sets up arrays for input/output conversion
LDRSEC	Provides for PRINT and READ mode entries into subroutine RTMODE
LEROY	Controls CalComp plotting with liquid ink pen
LINE	CalComp routine to draw a continuous line and/or a symbol
MASCNT	Performs matrix algebra operations
NAMECRT	Identifies and initializes usage of the CRT console
NM218	Initializes usage of typewriter
NOTATE	Draws alphanumeric characters for CalComp plots

<u>Subroutine</u>	<u>Description</u>
NUMBER	Draws floating point numbers for CalComp plots
OPERATE	Causes readout of DAC and LDISO arrays and readin of LDISI array
PCCEXEC	Controls overlay loading for RTS jobs
PLAYBAK	Plays back data recorded on real-time disk file, one frame at a time
PRINTER	Causes routing of MF disk file to printer
PSEUDO	Saves plotting information in order to use CalComp postprocessor
READOUT	Specifies quantities to be recorded and frequency of recording for the real-time disk file
READY	Signals that the program is ready for real-time operation
RECIN	Inputs flight test data
RECORD	Records quantities as specified in subroutine READOUT
RECYCLE	Signals end of a cycle when in the OPERATE mode and returns to address specified by subroutine CYCLE
RITECRT	Issues plotting requests to CRT system
RTMODE	Entry into the mode control routine
SCANNER	Increments display address
TYPEVAR	Types out data displayed on DDDU
UNLODE	Erases data stored on CRT file
XDSPLAY	Initializes data entry keyboard and DDDU, and routes program listing

## OVERLAY Program Descriptions, Flow Charts, and Listings

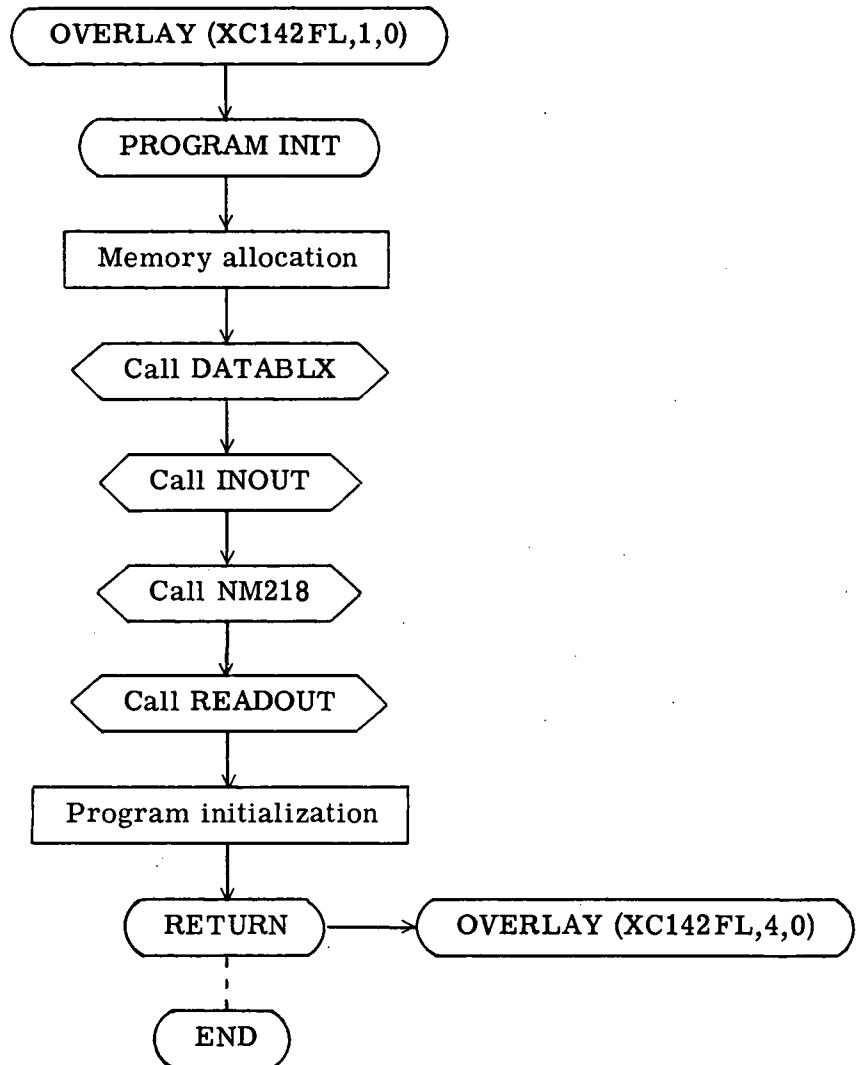
The program uses RTS central memory overlay capabilities controlled by subroutine PCCEXEC where level (4,0) is the real-time operational level. A brief description, flow chart, and FORTRAN source listing are presented for each overlay level (excluding subroutines previously described).

OVERLAY(XC142FL,0,0). - The main overlay, level (0,0), is always resident in central memory. It includes the labeled COMMON, the initial call to subroutine PCCEXEC, and other system initialization calls.



OVERLAY(XC142FL,0,0)	A 0001
PROGRAM XC142A(INPUT,OUTPUT)	A 0002
LOGICAL LDISI,LDISO,LOGIC,VARCHNG	A 0003
COMMON /INTCOMM/ T,H,INT,NEG,ISCHEME,DERINT(2,249)	A 0004
COMMON /INTINTR/ INTERN(5,249)	A 0005
COMMON /REALTIM/ ADC(32),DAC(64),LDISI(108),LDISO(196),NOPER,NMOLD	A 0006
1,NRESET,NTERM,NPRINT,NREAD	A 0007
COMMON /ALGOR/ NPAR,IPAR,INTP(30),IP,INTV(8),IV,INTA(11),IA,IA1,IA	A 0008
12,PARAM(40),DPARAM(30),ALV(11),DVAR(8),DALG(11),ALG(40),IAC(40),IE	A 0009
2VEN,WT(11,11),COM,L1,L2	A 0010
COMMON /COMM1/ IRR,IPL,ISL,TABLE(199),INTEG(99),LOGIC(20),NTAB,NIN	A 0011
1T,NLOG,NADC,NDAC,NLDI,NLDO,NT,AXI,AYI,AZI,ORAD,RAOD,PI,IR(2),NRN,N	A 0012
2PTS,ISKIP,JSKIP,KSKIP,MF,TX,TY,TZ,AMX,AMY,AMZ,VARCHNG,ITYPE,IVARBU	A 0013
3F(5),DELX,NOITSPS,PTSINV	A 0014
COMMON /COMM2/ MAXPAGE,LABT,LABU,LABV,LABW,LABP,LABQ,LABR,LABTH,LA	A 0015
1BPH,LABAX,LABAY,LABAZ,LABDA,LABDE,LABOR,FET25(17),LUN25,NAM25,ITRN	A 0016
2MLT(7),IMULTA(7),INVSEN(7),IMULTB(7),INVWT(7)	A 0017
COMMON /FLIGHT/ UM(201),VM(201),WM(201),PM(201),QM(201),RM(201),TH	A 0018
1M(201),PHM(201),AXM(201),AYM(201),AZM(201),FDA(201),FDE(201),FDR(2	A 0019
201),FBT(201),FDB(201),FDELB(201),FPPER(201),FTPER(201),BETAT,ETA,E	A 0020
3TAT,FCT(12),CTT,CT	A 0021
CALL PSEUDO	A 0022
CALL NAMECRT (6LCRTTPE,IRR)	A 0023
XC142FL=7LXC142FL	A 0024
CALL PCCEXEC (XC142FL,MF,90034S,LDISI,IPL,ISL)	A 0025
CALL DSPLAY	A 0026
CALL CLRTABL	A 0027
90034 FORMAT (54H XC-142A C1123 13927T S. C. MAYHEW ROOM 2131C)	A 0028
END	A 0029

OVERLAY (XC142FL,1,0).- The initialization overlay, level (1,0), is automatically loaded by the initial call to subroutine PCCEXEC. Upon completion of level (1,0), overlay (4,0) is automatically loaded.



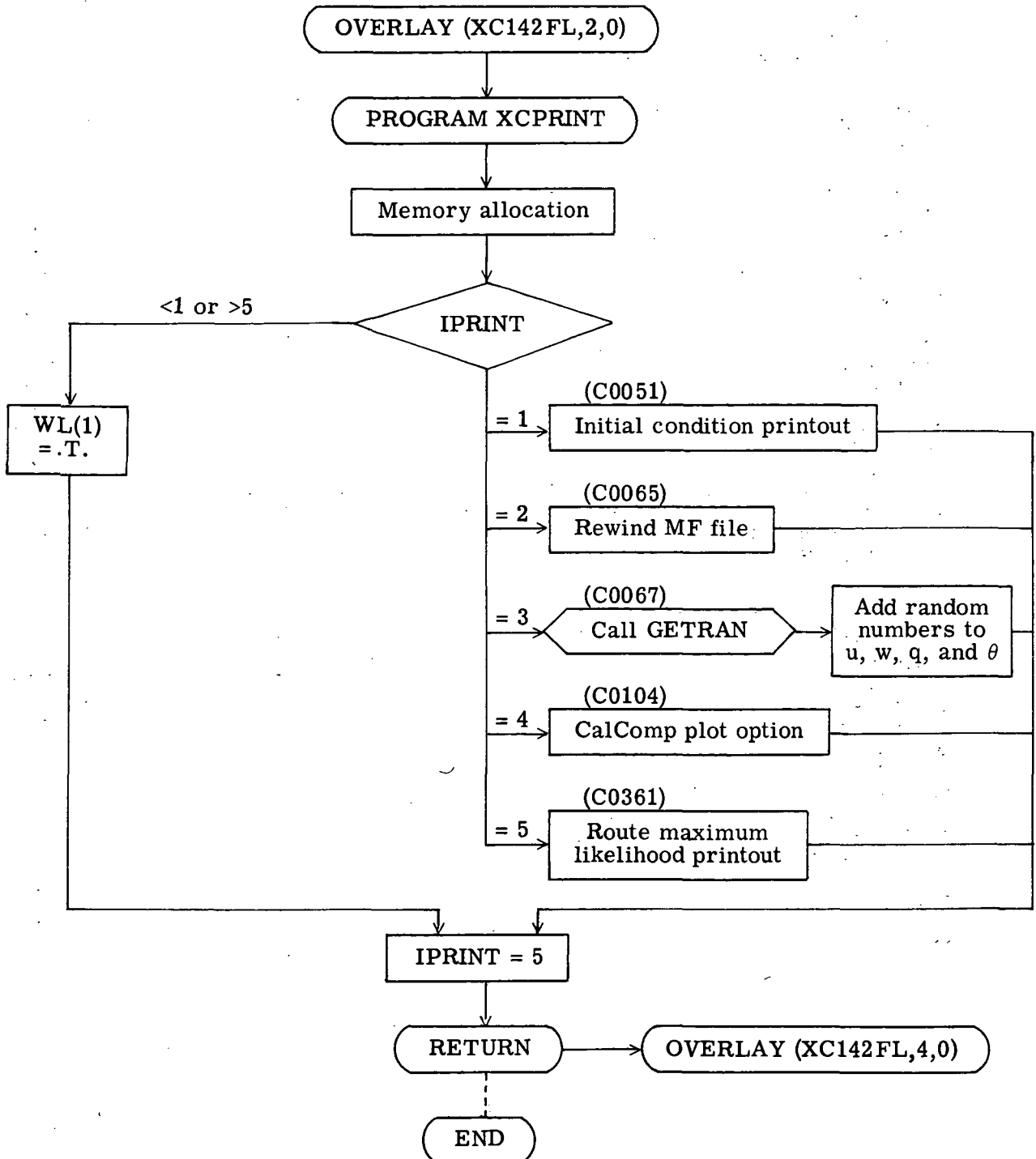
OVERLAY(XC142FL,1,0)	B 0001
PROGRAM INIT	B 0002
LOGICAL LDIS1,LDISO,LOGIC,VARCHNG	B 0003
DIMENSION AL(40),INTX(8),INTY(11)	B 0004
COMMON /INTCOMM/ T,H,INT,NEG,IScheme,DERINT(2,249)	B 0005
COMMON /INTINTR/ INTERN(5,249)	B 0006
COMMON /REALTIM/ ADC(32),DAC(64),LDIS1(108),LDISO(196),NOPER,NHOLD	B 0007
1,NRESET,NTerm,NPRINT,NREAD	B 0008
COMMON /ALGOR/ NPAR,IPAR,INTP(30),IP,INTV(8),IV,INTA(11),IA,IA1,IA	B 0009
12,PARAM(40),DPARAM(30),ALV(11),DVAR(8),DALG(11),ALG(40),IAC(40),IE	B 0010
2VEN,WT(11,11),COM,L1,L2	B 0011
COMMON /COMM1/ IRR,IPL,ISL,TABLE(199),INTEG(99),LOGIC(20),NTAB,NIN	B 0012
1T,NLOG,NADC,NDAC,NLDI,NLDO,NT,AXI,AYI,AZI,DRAD,RADD,PI,IR(2),NRN,N	B 0013
2PTS,ISKIP,JSKIP,KSKIP,MF,TX,TY,TZ,AMX,AMY,AMZ,VARCHNG,ITYPE,IVARBU	B 0014
3F(5),DELX,NOITSPS,PTSINV	B 0015
COMMON /COMM2/ MAXPAGE,LABT,LABU,LABV,LABW,LABP,LABQ,LABR,LABTH,LA	B 0016
1BPH,LABAX,LABAY,LABAZ,LABDA,LABDE,LABDR,FET25(17),LUN25,NAM25,ITRN	B 0017
2MLT(7),IMULTA(7),INVSEN(7),IMULTB(7),INVWT(7)	B 0018
COMMON /FLIGHT/ UM(201),VM(201),WM(201),PM(201),QM(201),RM(201),TH	B 0019
1M(201),PHM(201),AXM(201),AYM(201),AZM(201),FDA(201),FDE(201),FDR(2	B 0020
201),FBT(201),FDB(201),FDELB(201),FPPER(201),FTPER(201),BETAT,ETA,E	B 0021
3TAT,FCT(12),CTT,CT	B 0022
DATA PARAM/2HU0,3HCX0,4HCXAL,3HCXQ,4HTHEO,4HPHI0,2HWO,3HCZO,4HCZAL	B 0023
1,3HCZQ,4HCZDE,2HQ0,3HCM0,4HCMAL,5HCMALD,3HCMQ,4HCMDE,2HVO,3HCYO,3H	B 0024
2CYB,4HCYBD,3HCYP,3HCYR,4HCYDR,2HPO,3HCL0,3HCLB,4HCLBD,3HCLP,3HCLR,	B 0025
34HCLDR,4HCLDA,2HRO,3HCNO,3HCNB,4HCNBD,3HCNP,3HCNR,4HCNDR,4HCNDA/	B 0026
DATA ALV/1HU,1HV,1HW,1HP,1HQ,1HR,3HTHE,3HPHI,3HAXI,3HAYI,3HAZI/	B 0027
DATA FCT/0,008,025,046,072,097,125,151,174,193,208,22/	B 0028
EQUIVALENCE (DERINT(1,1),U), (DERINT(1,2),V), (DERINT(1,3),W), (DE	B 0029
1RINT(1,4),P), (DERINT(1,5),Q), (DERINT(1,6),R), (DERINT(1,7),THE),	B 0030
2 (DERINT(1,8),PHI), (AL(1),UO), (AL(2),CX0), (AL(3),CXAL), (AL(7),	B 0031
3WO), (AL(8),CZO), (AL(9),CZAL), (AL(12),QO), (AL(14),CMAL), (AL(16	B 0032
4),CMQ), (AL(18),VO), (AL(20),CYB), (AL(22),CYP), (AL(23),CYR), (AL	B 0033
5(25),PO), (AL(27),CLB), (AL(29),CLP), (AL(30),CLR), (AL(33),RO), (	B 0034
6AL(35),CNB), (AL(37),CNP), (AL(38),CNR), (TABLE(1),AL(1)), (TABLE(	B 0035
750),UMAX), (TABLE(51),VMAX), (TABLE(52),WMAX), (TABLE(53),PMAX), (	B 0036
8TABLE(54),QMAX), (TABLE(55),RMAX), (TABLE(56),THMAX), (TABLE(57),P	B 0037
9HMAX), (TABLE(58),AXMAX), (TABLE(59),AYMAX), (TABLE(60),AZMAX), (T	B 0038
\$ABLE(62),DAMAX), (TABLE(63),DEMAX), (TABLE(64),DRMAX), (TABLE(99),	B 0039
\$PASS), (TABLE(117),AIX), (TABLE(118),AIY), (TABLE(119),AIZ), (TABL	B 0040
\$E(121),WEIGHT), (TABLE(122),GRAV), (TABLE(123),RHO), (TABLE(124),S	B 0041
\$), (TABLE(125),B), (TABLE(126),CBAR), (TABLE(128),DEFREQ), (TABLE(	B 0042
\$130),DT), (TABLE(131),TT), (TABLE(133),TIMF), (TABLE(154),XX), (TA	B 0043
\$BLE(155),YX), (TABLE(156),ZX), (TABLE(157),XY), (TABLE(158),YY), (	B 0044
\$TABLE(159),ZY), (TABLE(160),XZ), (TABLE(161),YZ), (TABLE(162),ZZ)	B 0045
EQUIVALENCE (TABLE(170),DALMLT), (TABLE(171),UCRTBI), (TABLE(173),	B 0046
1CTO), (TABLE(177),D), (INTEG(51),INTY(1)), (INTEG(62),NOPTS), (INT	B 0047
2EG(63),INC), (INTEG(64),IPRINT), (INTEG(65),NPLOT), (INTEG(66),IRE	B 0048
3AD), (INTEG(67),KSCAN), (INTEG(81),INTX(1))	B 0049
IScheme=3	B 0050
NPAR=40	B 0051
IPAR=30	B 0052
IEVEN=-1	B 0053
COM=1H,	C 0054
L1=8H LOGIC(	C 0055
L2=2H)=	C 0056
IPL=4	B 0057
ISL=0	B 0058
NTAB=199	B 0059
DO 10 I=1,NTAB	B 0060

10	TABLE(I)=0.	B 0061
	DO 20 I=65.78	B 0062
20	TABLE(I)=1.	B 0063
	NINT=99	B 0064
	DO 30 I=1,NINT	B 0065
30	INTEG(I)=0	B 0066
	NLOG=20	B 0067
	DO 40 I=1,NLOG	B 0068
40	LOGIC(I)=.F.	B 0069
	LOGIC(1)=.T.	B 0070
	LOGIC(2)=.T.	B 0071
	NADC=0	B 0072
	NDAC=8	B 0073
	NLDI=48	B 0074
	DO 50 I=1,NLDI	B 0075
50	LDISI(I)=.F.	B 0076
	NLDO=180	B 0077
	DO 60 I=1,NLDO	B 0078
60	LDISO(I)=.FALSE.	B 0079
	CALL DATBLX (TABLE,NTAB,INTEG,NINT,LOGIC,NLOG,ADC,NADC,DAC,NDAC,L	B 0080
	IDISI,NLDI,LDISO,NLDO)	B 0081
	CALL INOUT (ADC,NADC,DAC,NDAC,LDISI,NLDI,LDISO,NLDO)	B 0082
	CALL NM218 (5LOSCAR)	B 0083
	NT=1	B 0084
	CALL READOUT (6,NT,U,V,W,P,Q,R)	B 0085
	CALL READOUT (6,NT,T,THE,PHI,AXI,AYI,AZI)	B 0086
	DRAD=57.2958	B 0087
	RADD=1./DRAD	B 0088
	PI=3.141593	B 0089
	IR(1)=13	B 0090
	IR(2)=2357	B 0091
	NRN=4	B 0092
	NPTS=201	B 0093
	ISKIP=JSKIP=KSKIP=0	B 0094
	TY=0.	B 0095
	MAXPAGE=10	B 0096
	LABT=10HTIME (SEC)	B 0097
	LABU=10HU (FT/SEC)	B 0098
	LABV=10HV (FT/SEC)	B 0099
	LABW=10HW (FT/SEC)	B 0100
	LABP=10HP (RAD/SEC)	B 0101
	LABQ=10HQ (RAD/SEC)	B 0102
	LABR=10HR (RAD/SEC)	B 0103
	LABTH=10HTheta (RAD)	B 0104
	LABPH=10HPhi (RAD)	B 0105
	LABAX=10HAXI (G)	B 0106
	LABAY=10HAYI (G)	B 0107
	LABAZ=10HAZI (G)	B 0108
	LABDA=10HDA (RAD)	B 0109
	LABDE=10HDE (RAD)	B 0110
	LABDR=10HDR (RAD)	B 0111
	NAM25=6LTAPE25	B 0112
	DO 70 I=1,7	B 0113
	ITRNMLT(I)=0	B 0114
	IMULTA(I)=0	B 0115
	IMULTB(I)=0	B 0116
	INVSEN(I)=0	B 0117

70	INVWT(1)=0	B 0118
	ITRNMLT(1)=23	B 0119
	ITRNMLT(5)=ITRNMLT(6)=IMULTA(6)=INVWT(5)=11	B 0120
	ITRNMLT(7)=IMULTA(5)=IMULTA(7)=INVSEN(5)=IMULTB(5)=IMULTB(6)=IPAR	B 0121
	IMULTB(7)=IPAR	B 0122
	IMULTA(1)=IMULTB(1)=20	B 0123
	IMULTA(4)=IMULTB(4)=1	B 0124
	INVSEN(1)=INVWT(1)=10	B 0125
	INVSEN(4)=INVWT(4)=2	B 0126
	UMAX=20.	B 0127
	VMAX=40.	B 0128
	WMAX=10.	B 0129
	PMAX=QMAX=RMAX=.2	B 0130
	THMAX=PHMAX=AXMAX=AYMAX=.4	B 0131
	AZMAX=2.	B 0132
	DAMAX=DEMAX=DRMAX=.1	B 0133
	PASS=-1.	B 0134
	AIX=150000.	B 0135
	AIY=128000.	B 0136
	AIZ=270000.	B 0137
	WEIGHT=36050.	B 0138
	GRAV=32.17	B 0139
	RHO=.002242	B 0140
	S=534.	B 0141
	B=67.5	B 0142
	CBAR=8.07	B 0143
	DEFREQ=1.	B 0144
	DT=.03125	B 0145
	TT=.03125	B 0146
	TIMF=10.	B 0147
	XX=10.	B 0148
	YX=2.	B 0149
	ZX=5.	B 0150
	XY=7.	B 0151
	YY=9.	B 0152
	ZY=4.	B 0153
	XZ=2.	B 0154
	YZ=5.	B 0155
	ZZ=7.	B 0156
	DALMLT=1.	B 0157
	UCRTBI=200.	B 0158
	CTO=.03	B 0159
	D=15.5	B 0160
	DO 80 I=1,8	B 0161
	INTX(1)=1	B 0162

80	INTY(1)=1	B 0163
	NOPTS=81	B 0164
	INC=4	B 0165
	IPRINT=1	B 0166
	NPLOT=2	B 0167
	IREAD=1	B 0168
	KSCAN=2	B 0169
	ETA=1232.*.75/60.	B 0170
	UO=120.*1.689	B 0171
	TMP=S*UO**2	B 0172
	CXO=-8.*ETA**2*D**4*CTO/TMP	B 0173
	CXAL=-0.29	B 0174
	WO=5.	B 0175
	CZO=-2.*WEIGHT/(RHO*TMP)	B 0176
	CZAL=-4.30	B 0177
	QO=-.15	B 0178
	CMAL=-1.49	B 0179
	CMQ=-31.14	B 0180
	VO=10.	B 0181
	CYB=-1.70	B 0182
	CYP=0.50	B 0183
	CYR=0.40	B 0184
	PO=-.15	B 0185
	CLB=-0.18	B 0186
	CLP=-0.72	B 0187
	CLR=0.20	B 0188
	RO=.15	B 0189
	CNB=0.06	B 0190
	CNP=0.05	B 0191
	CNR=-0.70	B 0192
	INTEG(2)=INTEG(8)=INTEG(9)=INTEG(14)=INTEG(16)=INTEG(20)=1	B 0193
	INTEG(22)=INTEG(23)=INTEG(27)=INTEG(29)=INTEG(30)=INTEG(35)=1	B 0194
	INTEG(37)=INTEG(38)=1	B 0195
	DO 90 I=1,NPAR	B 0196
	ALG(1)=AL(1)	B 0197
90	IAC(1)=INTEG(1)	B 0198
	ALG(2)=-.1	B 0199
	ALG(8)=-1.	B 0200
	ALG(9)=-3.	B 0201
	ALG(14)=-1.	B 0202
	ALG(16)=-22	B 0203
	ALG(20)=0.	B 0204
	ALG(22)=.3	B 0205
	ALG(23)=.2	B 0206
	ALG(27)=-.13	B 0207
	ALG(29)=-.4	B 0208
	ALG(30)=.15	B 0209
	ALG(35)=.03	B 0210
	ALG(37)=.02	B 0211
	ALG(38)=-.4	B 0212
	RETURN	B 0213
	END	B 0214

OVERLAY (XC142FL,2,0).- The print overlay, level (2,0), is loaded when the PRINT mode is selected on the program control console. The integer IPRINT, preset in level (4,0), selects one of the five options in the PRINT overlay. The CalComp plot option is presented in appendix E. The primary overlay, level (4,0), is automatically loaded upon completion of level (2,0).



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OVERLAY(XC142FL,2,0) C 0001
PROGRAM XCPRI NT C 0002
LOGICAL FSS(16),LDISI,LDISO,LOGIC,VARCHNG,WL(39) C 0003
DIMENSION X(203),Y1(203),Y2(203),Y3(203),Y4(203),Z1(203),Z2( C 0004
1203),Z3(203),Z4(203),DATE(2),DRM(4),DRSD(4),RAN(4,201),RN(4 C 0005
2),RSD(4) C 0006
COMMON /INTCOMM/ T,H,INT,NEQ,ISCHEME,DERINT(2,249) C 0007
COMMON /INTINTR/ INTERN(5,249) C 0008
COMMON /REALTIM/ ADC(32),DAC(64),LDISI(108),LDISO(196),NOPER,NHOLD C 0009
1,NRESET,NTERM,NPRINT,NREAD C 0010
COMMON /ALGOR/ NPAR,IPAR,INTP(30),IP,INTV(8),IV,INTA(11),IA,IAI,IA C 0011
12,PARAM(40),DPARAM(30),ALV(11),DVAR(8),DALG(11),ALG(40),IAC(40),IE C 0012
2VEN,WT(11,11),COM,L1,L2 C 0013
COMMON /COMM1/ IRR,IPL,ISL,TABLE(199),INTEG(99),LOGIC(20),NTAB,NIN C 0014
1T,NLOG,NADC,NDAC,NLDI,NLDO,NT,AXI,AYI,AZI,DRAD,RADD,PI,IR(2),NRN,N C 0015
2PTS,ISKIP,JSKIP,KSKIP,MF,TX,TY,TZ,AMX,AMY,AMZ,VARCHNG,ITYPE,IVARBU C 0016
3F(5),DELX,NOITSPS,PTSINV C 0017
COMMON /COMM2/ MAXPAGE,LABT,LABU,LABV,LABW,LABP,LABQ,LABR,LABTH,LA C 0018
1BPH,LABAX,LABAY,LABAZ,LABDA,LABDE,LABDR,FET25(17),LUN25,NAM25,ITRN C 0019
2MLT(7),IMULTA(7),INVSEN(7),IMULTB(7),INVWT(7) C 0020
COMMON /FLIGHT/ UM(201),VM(201),WM(201),PM(201),QM(201),RM(201),TH C 0021
1M(201),PHM(201),AXM(201),AYM(201),AZM(201),FDA(201),FDE(201),FDR(2 C 0022
201),FBT(201),FDB(201),FDELB(201),FPPER(201),FTPER(201),BETAT,ETA,E C 0023
3TAT,CTT(12),CTT,CT C 0024
EQUIVALENCE (DERINT(1,1),U), (DERINT(1,2),V), (DERINT(1,3),W), (DE C 0025
1RINT(1,4),P), (DERINT(1,5),Q), (DERINT(1,6),R), (DERINT(1,7),THE), C 0026
2 (DERINT(1,8),PHI), (LDISO(61),WL(1)), (FSS(1),LDISI(33)), (TABLE( C 0027
350),UMAX), (TABLE(51),VMAX), (TABLE(52),WMAX), (TABLE(53),PMAX), ( C 0028
4TABLE(54),QMAX), (TABLE(55),RMAX), (TABLE(56),THMAX), (TABLE(57),P C 0029
5HMAX), (TABLE(58),AXMAX), (TABLE(59),AYMAX), (TABLE(60),AZMAX), (T C 0030
6ABLE(62),DAMAX), (TABLE(63),DEMAX), (TABLE(64),DRMAX), (TABLE(98), C 0031
7RUN), (TABLE(99),PASS), (TABLE(101),DRM(1)), (TABLE(171),UCRTBI), C 0032
8(TABLE(191),DRSD(1)), (INTEG(62),NOPTS), (INTEG(64),IPRINT), (INTE C 0033
9G(65),NPLOT) C 0034
C IPRINT=1 TO PRINT ICS C 0035
C IPRINT=2 TO REWIND MF FILE C 0036
C IPRINT=3 TO OBTAIN RANDOM NUMBERS C 0037
C IPRINT=4 FOR CALCOMP PLOT (SET VALUE BEFORE EXITING CRT LOOP AND C 0038
ENTERING PRINT - USES FSS(1,2,7,8,13,14)) C 0039
C IPRINT=5 TO RETURN (ROUTES OUTPUT) C 0040
C WL(1) INDICATES DEFAULT VALUE USED FOR IPRINT C 0041
C WL(2) INDICATES CALCOMP PLOT COMPLETED C 0042
C WL(3) INDICATES ERROR IN CALCOMP PLOT LOOP C 0043
L=IPRINT C 0044
IPRINT=5 C 0045
WL(1)=.F. C 0046
IF ((L.GE.1).AND.(L.LE.5)) GO TO 10 C 0047
WL(1)=.T. C 0048
RETURN C 0049
10 GO TO (20,30,40,120,340), L C 0050
20 IEVEN=-1 C 0051
RUN=RUN+1. C 0052
PASS=-1. C 0053
WRITE (MF,350) RUN,((L1,1,L2,LOGIC(1)),I=1,11) C 0054
WRITE (MF,360) DVAR(1),((COM,DVAR(1)),I=2,IV) C 0055
WRITE (MF,370) DALG(1),((COM,DALG(1)),I=2,IA) C 0056
WRITE (MF,380) ((PARAM(I),TABLE(I),INTEG(I)),I=1,NPAR) C 0057
WRITE (MF,390) (TABLE(I),I=65,92) C 0058
WRITE (MF,400) (TABLE(I),I=117,133) C 0059
WRITE (MF,410) (TABLE(I),I=154,162) C 0060
WRITE (MF,420) (TABLE(I),I=169,186) C 0061
WRITE (MF,430) TX,TY,TZ,AMX,AMY,AMZ C 0062
WRITE (MF,440) INTEG(62),INTEG(63) C 0063
RETURN C 0064

```

30	REWIND MF	C 0065
	RETURN	C 0066
40	CALL GETRAN (IR,1,2,DMY,Y1,Y2)	C 0067
	DO 50 I=1,NRN	C 0068
	DO 50 J=1,NPTS	C 0069
	CALL GETRAN (IR,2,2,RAN(I,J),Y1,Y2)	C 0070
50	CONTINUE	C 0071
	DO 60 I=1,NRN	C 0072
	RN(I)=0.	C 0073
	RSD(I)=0.	C 0074
	DO 60 J=1,NOPTS	C 0075
	RN(I)=RN(I)+RAN(I,J)	C 0076
60	RSD(I)=RSD(I)+RAN(I,J)**2	C 0077
	DO 70 I=1,NRN	C 0078
	RN(I)=RN(I)*PTSINV	C 0079
	RSD(I)=SQRT(RSD(I)*PTSINV-RN(I)**2)	C 0080
	RSD(I)=DRSD(I)/RSD(I)	C 0081
70	RN(I)=DRM(I)-RSD(I)*RN(I)	C 0082
	DO 80 I=1,NRN	C 0083
	DO 80 J=1,NOPTS	C 0084
	RAN(I,J)=RAN(I,J)*RSD(I)+RN(I)	C 0085
80	CONTINUE	C 0086
	DO 90 I=1,NRN	C 0087
	RN(I)=0.	C 0088
	RSD(I)=0.	C 0089
	DO 90 J=1,NOPTS	C 0090
	RN(I)=RN(I)+RAN(I,J)	C 0091
90	RSD(I)=RSD(I)+RAN(I,J)**2	C 0092
	DO 100 I=1,NRN	C 0093
	RN(I)=RN(I)*PTSINV	C 0094
	RSD(I)=SQRT(RSD(I)*PTSINV-RN(I)**2)	C 0095
100	CONTINUE	C 0096
	DO 110 I=1,NOPTS	C 0097
	UM(I)=UM(I)+RAN(1,I)	C 0098
	WM(I)=WM(I)+RAN(2,I)	C 0099
	QM(I)=QM(I)+RAN(3,I)	C 0100
110	THM(I)=THM(I)+RAN(4,I)	C 0101
	WRITE (MF,450) RUN,NOPTS,((DRM(I),RN(I),DRSD(I),RSD(I)),I=1,NRN)	C 0102
	RETURN	C 0103
120	WL(3)=.F.	C 0104
	IF (JSKIP.GT.0) GO TO 130	C 0105
	CALL CALPLT (0.,0.,-3)	C 0106
	CALL LEROY	C 0107
C	K=-1 FOR SYMBOL EVERY DATA POINT	C 0108
C	K=-2 FOR SYMBOL EVERY OTHER DATA POINT,ETC.	C 0109
130	K=-NPLT	C 0110
	JSKIP=JSKIP+1	C 0111
	BI=SF4=0.	C 0112
	IF (.,NOT.FSS(1)) GO TO 140	C 0113
	SF1=AZMAX	C 0114
	SF2=AYMAX	C 0115
	SF3=AXMAX	C 0116
	GO TO 170	C 0117
140	IF (.,NOT.FSS(7)) GO TO 150	C 0118
	SF1=PHMAX	C 0119
	SF2=VMAX	C 0120
	SF3=RMAX	C 0121
	SF4=PMAX	C 0122
	GO TO 170	C 0123
150	IF (.,NOT.FSS(8)) GO TO 160	C 0124
	SF1=DRMAX	C 0125
	SF2=DEMAX	C 0126
	SF3=DAMAX	C 0127
	GO TO 170	C 0128

160	SF1=THMAX	C 0129
	SF2=QMAX	C 0130
	SF3=WMAX	C 0131
	SF4=UMAX	C 0132
	B1=UCRTBI	C 0133
170	ZT=B1+SF4	C 0134
	ZB=B1-SF4	C 0135
	IF (FSS(2).OR.FSS(8)) GO TO 220	C 0136
	I=0	C 0137
	J=-1	C 0138
180	CALL PLAYBAK(215S)	C 0139
	J=J+1	C 0140
	IF (MOD(J,NOITSPS).GT.0) GO TO 180	C 0141
	I=I+1	C 0142
	IF (I.GT.NOPTS) GO TO 180	C 0143
	IF (.NOT.FSS(1)) GO TO 190	C 0144
	Y1(I)=AZI	C 0145
	Y2(I)=AYI	C 0146
	Y3(I)=AXI	C 0147
	Y4(I)=0.	C 0148
	GO TO 210	C 0149
190	IF (.NOT.FSS(7)) GO TO 200	C 0150
	Y1(I)=PHI	C 0151
	Y2(I)=V	C 0152
	Y3(I)=R	C 0153
	Y4(I)=P	C 0154
	GO TO 210	C 0155
200	Y1(I)=THE	C 0156
	Y2(I)=Q	C 0157
	Y3(I)=W	C 0158
	Y4(I)=U	C 0159
210	IF (Y1(I).GT.SF1) Y1(I)=SF1	C 0160
	IF (Y2(I).GT.SF2) Y2(I)=SF2	C 0161
	IF (Y3(I).GT.SF3) Y3(I)=SF3	C 0162
	IF (Y4(I).GT.ZT) Y4(I)=ZT	C 0163
	IF (Y1(I).LT.-SF1) Y1(I)=-SF1	C 0164
	IF (Y2(I).LT.-SF2) Y2(I)=-SF2	C 0165
	IF (Y3(I).LT.-SF3) Y3(I)=-SF3	C 0166
	IF (Y4(I).LT.ZB) Y4(I)=ZB	C 0167
	GO TO 180	C 0168
215	IF (I.EQ.NOPTS) GO TO 220	C 0169
	WL(3)=.T.	C 0170
	RETURN	C 0171
220	DO 270 I=1,NOPTS	C 0172
	X(I)=DELX*(I-1)	C 0173
	IF (.NOT.FSS(1)) GO TO 230	C 0174
	Z1(I)=AZM(I)	C 0175
	Z2(I)=AYM(I)	C 0176
	Z3(I)=AXM(I)	C 0177
	Z4(I)=0.	C 0178
	GO TO 260	C 0179
230	IF (.NOT.FSS(7)) GO TO 240	C 0180
	Z1(I)=PHM(I)	C 0181
	Z2(I)=VM(I)	C 0182
	Z3(I)=RM(I)	C 0183
	Z4(I)=PM(I)	C 0184
	GO TO 260	C 0185
240	IF (.NOT.FSS(8)) GO TO 250	C 0186
	Z1(I)=FDR(I)	C 0187
	Z2(I)=FDE(I)	C 0188
	Z3(I)=FDA(I)	C 0189
	Z4(I)=0.	C 0190
	GO TO 260	C 0191

250	Z1(1)=THM(1)	C 0192
	Z2(1)=QM(1)	C 0193
	Z3(1)=WM(1)	C 0194
	Z4(1)=UM(1)	C 0195
260	IF (Z1(1).GT.SF1) Z1(1)=SF1	C 0196
	IF (Z2(1).GT.SF2) Z2(1)=SF2	C 0197
	IF (Z3(1).GT.SF3) Z3(1)=SF3	C 0198
	IF (Z4(1).GT.ZT) Z4(1)=ZT	C 0199
	IF (Z1(1).LT.-SF1) Z1(1)=-SF1	C 0200
	IF (Z2(1).LT.-SF2) Z2(1)=-SF2	C 0201
	IF (Z3(1).LT.-SF3) Z3(1)=-SF3	C 0202
	IF (Z4(1).LT.ZB) Z4(1)=ZB	C 0203
270	CONTINUE	C 0204
	CALL DAYTIM (DATE)	C 0205
	CALL NOTATE (-1.5,0.0,.07,DATE(1),90,.10)	C 0206
	CALL NOTATE (-1.5,2.4,.07,DATE(2),90,.10)	C 0207
	CALL NOTATE (-1.5,4.8,.07,7HRUN NO=90,.7)	C 0208
	CALL NUMBER (-1.5,6.5,.07,RUN,90,.1)	C 0209
	CALL NOTATE (-1.5,7.5,.07,5HITER=90,.5)	C 0210
	CALL NUMBER (-1.5,8.7,.07,PASS,90,.1)	C 0211
	CALL ASCALE (X,5,.NOPTS,1,10.)	C 0212
	LPT=NOPTS+1	C 0213
	JPT=NOPTS+2	C 0214
	XM=X(LPT)	C 0215
	XS=X(JPT)	C 0216
	CALL GRID (0,.0,.5,.5,10,4)	C 0217
	CALL AXES (0,.0,.0,.5,.XM,XS,1,.10,.LABT,.14,-10)	C 0218
	YM=-SF1	C 0219
	YS=SF1	C 0220
	Y1(LPT)=Z1(LPT)=YM	C 0221
	Y1(JPT)=Z1(JPT)=YS	C 0222
	IF (.NOT.FSS(1)) GO TO 280	C 0223
	CALL AXES (0,.0,.90,.2,.YM,YS,.5,10,.12HAZI(G UNITS),.14,12)	C 0224
	CALL LINE (X,Z1,NOPTS,1,K,3,.07)	C 0225
	IF (.NOT.FSS(2)) CALL LINE (X,Y1,NOPTS,1,0,0,.07)	C 0226
	CALL CALPLT (0,.2,75,-3)	C 0227
	CALL GRID (0,.0,.5,.5,10,4)	C 0228
	CALL AXES (0,.0,.0,.5,.XM,XS,1,.10,.LABT,.14,-10)	C 0229
	YM=-SF2	C 0230
	YS=SF2	C 0231
	Y2(LPT)=Z2(LPT)=YM	C 0232
	Y2(JPT)=Z2(JPT)=YS	C 0233
	CALL AXES (0,.0,.90,.2,.YM,YS,.5,10,.12HAYI(G UNITS),.14,12)	C 0234
	CALL LINE (X,Z2,NOPTS,1,K,3,.07)	C 0235
	IF (.NOT.FSS(2)) CALL LINE (X,Y2,NOPTS,1,0,0,.07)	C 0236
	CALL CALPLT (0,.2,75,-3)	C 0237
	CALL GRID (0,.0,.5,.5,10,4)	C 0238
	CALL AXES (0,.0,.0,.5,.XM,XS,1,.10,.LABT,.14,-10)	C 0239
	YM=-SF3	C 0240
	YS=SF3	C 0241
	Y3(LPT)=Z3(LPT)=YM	C 0242
	Y3(JPT)=Z3(JPT)=YS	C 0243
	CALL AXES (0,.0,.90,.2,.YM,YS,.5,10,.12HAXI(G UNITS),.14,12)	C 0244
	CALL LINE (X,Z3,NOPTS,1,K,3,.07)	C 0245
	IF (.NOT.FSS(2)) CALL LINE (X,Y3,NOPTS,1,0,0,.07)	C 0246
	CALL CALPLT (12,-5,5,-3)	C 0247
	GO TO 310	C 0248

280	IF (.NOT.FSS(7)) GO TO 290	C 0249
	CALL AXES (0.,0.,90.,2.,YM,YS.,5,10.,LABPH.,14,10)	C 0250
	CALL LINE (X,Z1,NOPTS,1,K,3.,07)	C 0251
	IF (.NOT.FSS(2)) CALL LINE (X,Y1,NOPTS,1,0,0.,07)	C 0252
	CALL CALPLT (0.,2.75,-3)	C 0253
	CALL GRID (0.,0.,5.,5,10,4)	C 0254
	CALL AXES (0.,0.,0.,5.,XM,XS,1.,10.,LABT.,14,-10)	C 0255
	YM=-SF2	C 0256
	YS=SF2	C 0257
	Y2(LPT)=Z2(LPT)=YM	C 0258
	Y2(JPT)=Z2(JPT)=YS	C 0259
	CALL AXES (0.,0.,90.,2.,YM,YS.,5,10.,LABV.,14,10)	C 0260
	VMIN=YM*.3048	C 0261
	VMX=YS*.3048	C 0262
	CALL AXES (5.,0.,90.,2.,VMIN,VMX.,5,10.,9HV (M/SEC),14,-9)	C 0263
	CALL LINE (X,Z2,NOPTS,1,K,3.,07)	C 0264
	IF (.NOT.FSS(2)) CALL LINE (X,Y2,NOPTS,1,0,0.,07)	C 0265
	CALL CALPLT (0.,2.75,-3)	C 0266
	CALL GRID (0.,0.,5.,5,10,4)	C 0267
	CALL AXES (0.,0.,0.,5.,XM,XS,1.,10.,LABT.,14,-10)	C 0268
	YM=-SF3	C 0269
	YS=SF3	C 0270
	Y3(LPT)=Z3(LPT)=YM	C 0271
	Y3(JPT)=Z3(JPT)=YS	C 0272
	CALL AXES (0.,0.,90.,2.,YM,YS.,5,10.,LABR.,14,10)	C 0273
	CALL LINE (X,Z3,NOPTS,1,K,3.,07)	C 0274
	IF (.NOT.FSS(2)) CALL LINE (X,Y3,NOPTS,1,0,0.,07)	C 0275
	CALL CALPLT (0.,2.75,-3)	C 0276
	CALL GRID (0.,0.,5.,5,10,4)	C 0277
	CALL AXES (0.,0.,0.,5.,XM,XS,1.,10.,LABT.,14,-10)	C 0278
	YM=-SF4	C 0279
	YS=SF4	C 0280
	Y4(LPT)=Z4(LPT)=YM	C 0281
	Y4(JPT)=Z4(JPT)=YS	C 0282
	CALL AXES (0.,0.,90.,2.,YM,YS.,5,10.,LABP.,14,10)	C 0283
	CALL LINE (X,Z4,NOPTS,1,K,3.,07)	C 0284
	IF (.NOT.FSS(2)) CALL LINE (X,Y4,NOPTS,1,0,0.,07)	C 0285
	CALL CALPLT (12.,-8.25,-3)	C 0286
	GO TO 310	C 0287
290	IF (.NOT.FSS(8)) GO TO 300	C 0288
	CALL AXES (0.,0.,90.,2.,YM,YS.,5,10.,LABDR.,14,10)	C 0289
	CALL LINE (X,Z1,NOPTS,1,K,3.,07)	C 0290
	CALL CALPLT (0.,2.75,-3)	C 0291
	CALL GRID (0.,0.,5.,5,10,4)	C 0292
	CALL AXES (0.,0.,0.,5.,XM,XS,1.,10.,LABT.,14,-10)	C 0293
	YM=-SF2	C 0294
	YS=SF2	C 0295
	Y2(LPT)=Z2(LPT)=YM	C 0296
	Y2(JPT)=Z2(JPT)=YS	C 0297
	CALL AXES (0.,0.,90.,2.,YM,YS.,5,10.,LABDE.,14,10)	C 0298
	CALL LINE (X,Z2,NOPTS,1,K,3.,07)	C 0299
	CALL CALPLT (0.,2.75,-3)	C 0300
	CALL GRID (0.,0.,5.,5,10,4)	C 0301
	CALL AXES (0.,0.,0.,5.,XM,XS,1.,10.,LABT.,14,-10)	C 0302
	YM=-SF3	C 0303
	YS=SF3	C 0304
	Y3(LPT)=Z3(LPT)=YM	C 0305
	Y3(JPT)=Z3(JPT)=YS	C 0306
	CALL AXES (0.,0.,90.,2.,YM,YS.,5,10.,LABDA.,14,10)	C 0307
	CALL LINE (X,Z3,NOPTS,1,K,3.,07)	C 0308
	CALL CALPLT (12.,-5.5,-3)	C 0309
	GO TO 310	C 0310

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300  CONTINUE                                C 0311
      CALL AXES (0.,0.,90.,2.,YM,YS,.5,10.,LABTH,.14,10) C 0312
      CALL LINE (X,Z1,NOPTS,1,K,3,.07)          C 0313
      IF (.NOT.FSS(2)) CALL LINE (X,Y1,NOPTS,1,0,0,.07) C 0314
      CALL CALPLT (0.,2.75,-3)                  C 0315
      CALL GRID (0.,0.,.5,.5,10,4)              C 0316
      CALL AXES (0.,0.,0.,5.,XM,XS,1.,10.,LABT,.14,-10) C 0317
      YM=-SF2                                    C 0318
      YS=SF2                                     C 0319
      Y2(LPT)=Z2(LPT)=YM                       C 0320
      Y2(JPT)=Z2(JPT)=YS                       C 0321
      CALL AXES (0.,0.,90.,2.,YM,YS,.5,10.,LABQ,.14,10) C 0322
      CALL LINE (X,Z2,NOPTS,1,K,3,.07)          C 0323
      IF (.NOT.FSS(2)) CALL LINE (X,Y2,NOPTS,1,0,0,.07) C 0324
      CALL CALPLT (0.,2.75,-3)                  C 0325
      CALL GRID (0.,0.,.5,.5,10,4)              C 0326
      CALL AXES (0.,0.,0.,5.,XM,XS,1.,10.,LABT,.14,-10) C 0327
      YM=-SF3                                    C 0328
      YS=SF3                                     C 0329
      Y3(LPT)=Z3(LPT)=YM                       C 0330
      Y3(JPT)=Z3(JPT)=YS                       C 0331
      CALL AXES (0.,0.,90.,2.,YM,YS,.5,10.,LABW,.14,10) C 0332
      WMIN=YM*.3048                             C 0333
      WMX=YS*.3048                             C 0334
      CALL AXES (5.,0.,90.,2.,WMIN,WMX,.5,10.,9HW (M/SEC),.14,-9) C 0335
      CALL LINE (X,Z3,NOPTS,1,K,3,.07)          C 0336
      IF (.NOT.FSS(2)) CALL LINE (X,Y3,NOPTS,1,0,0,.07) C 0337
      CALL CALPLT (0.,2.75,-3)                  C 0338
      CALL GRID (0.,0.,.5,.5,10,4)              C 0339
      CALL AXES (0.,0.,0.,5.,XM,XS,1.,10.,LABT,.14,-10) C 0340
      YM=ZR                                       C 0341
      YS=SF4                                     C 0342
      Y4(LPT)=Z4(LPT)=YM                       C 0343
      Y4(JPT)=Z4(JPT)=YS                       C 0344
      CALL AXES (0.,0.,90.,2.,YM,YS,.5,10.,LABU,.14,10) C 0345
      UMIN=YM*.3048                             C 0346
      UMX=YS*.3048                             C 0347
      CALL AXES (5.,0.,90.,2.,UMIN,UMX,.5,10.,9HU (M/SEC),.14,-9) C 0348
      CALL LINE (X,Z4,NOPTS,1,K,3,.07)          C 0349
      IF (.NOT.FSS(2)) CALL LINE (X,Y4,NOPTS,1,0,0,.07) C 0350
      CALL CALPLT (12.,-8.25,-3)                C 0351
310  WL(2)=.T.                                  C 0352
320  CALL DISPLAY                               C 0353
      CALL OPERATE                              C 0354
      IF (.NOT.FSS(14)) GO TO 330               C 0355
      WL(2)=.F.                                 C 0356
      CALL OPERATE                              C 0357
      GO TO 130                                 C 0358
330  IF (.NOT.FSS(13)) GO TO 320               C 0359
      WL(2)=.F.                                 C 0360
340  RETURN                                    C 0361
350  FORMAT (///6H RUN=.F4,0/(6(A8,I2,A2,L1))) C 0362
360  FORMAT (/39H ACTIVE EQUATION VARIABLES ARE . . . ,A3,7(A1,A3)) C 0363
370  FORMAT (/39H ACTIVE ALGORITHM VARIABLES ARE . . . ,A3,10(A1,A3)) C 0364
380  FORMAT (/5(25H PARAM VALUE ACT)/(5(2XA5,1XE13.6,1XL3))) C 0365
390  FORMAT (/9H UMULT =,E13.6,9H VMULT =,E13.6,9H WMULT =,E13.6,9H C 0366
      1 PMULT =,E13.6,9H QMULT =,E13.6,9H RMULT =,E13.6,9H THMULT=,E13 C 0367
      2.6,9H PHMULT=,E13.6,9H AXMULT=,E13.6,9H AYMULT=,E13.6,9H AZMUL C 0368
      3T=,E13.6,9H DAMULT=,E13.6,9H DEMULT=,E13.6,9H DRMULT=,E13.6,9H C 0369
      4 UBIAS =,E13.6,9H VBIAS =,E13.6,9H WBIAS =,E13.6,9H PBIAS =,E13 C 0370
      5.6,9H QBIAS =,E13.6,9H RBIAS =,E13.6,9H THBIAS=,E13.6,9H PHBIA C 0371
      6S=,E13.6,9H AXBIAS=,E13.6,9H AYBIAS=,E13.6,9H AZBIAS=,E13.6,9H C 0372
      7 DABIAS=,E13.6,9H DEBIAS=,E13.6,9H DRBIAS=,E13.6) C 0373

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400  FORMAT (/9H AIX  =,E13.6,9H AIY  =,E13.6,9H AIZ  =,E13.6,9H C 0374
1 AIXZ =,E13.6,9H WEIGHT=,E13.6,9H GRAV  =,E13.6/9H RHO  =,E13 C 0375
2.6,9H S  =,E13.6,9H B  =,E13.6,9H CBAR  =,E13.6,9H DEAMP C 0376
3L=,E13.6,9H DEFREQ=,E13.6/9H ALPHAT=,E13.6,9H DT  =,E13.6,9H C 0377
4 TT  =,E13.6,9H TS  =,E13.6,9H TIMF  =,E13.6) C 0378
410  FORMAT (/9H XX  =,E13.6,9H YX  =,E13.6,9H ZX  =,E13.6,9H C 0379
1 XY  =,E13.6,9H YY  =,E13.6,9H ZY  =,E13.6/9H XZ  =,E13 C 0380
2.6,9H YZ  =,E13.6,9H ZZ  =,E13.6) C 0381
420  FORMAT (/9H CMCON =,E13.6,9H DALMLT=,E13.6,9H UCRTBI=,E13.6,9H C 0382
1 AIW  =,E13.6,9H CTO  =,E13.6,9H CTT0  =,E13.6/9H CTB  =,E13 C 0383
2.6,9H CTBT =,E13.6,9H D  =,E13.6,9H CAPDT =,E13.6,9H ELBAR C 0384
3 =,E13.6,9H ELTP  =,E13.6/9H RB  =,E13.6,9H PPER  =,E13.6,9H C 0385
4 TPER  =,E13.6,9H BTBIAS=,E13.6,9H PPERBI=,E13.6,9H TPERBI=,E13 C 0386
5.6) C 0387
430  FORMAT (/9H TX  =,E13.6,9H TY  =,E13.6,9H TZ  =,E13.6,9H C 0388
1 AMX  =,E13.6,9H AMY  =,E13.6,9H AMZ  =,E13.6) C 0389
440  FORMAT (/8H NOPTS=,I4.6H INC=,I4) C 0390
450  FORMAT (///6H RUN=,F4.0,8H NOPTS=,I4///5X,6HHRM(1),9X,5HRN(1),9X C 0391
1.7HORS(1),9X,6HRS(1)///4(2XE13.6))) C 0392
END C 0393

```

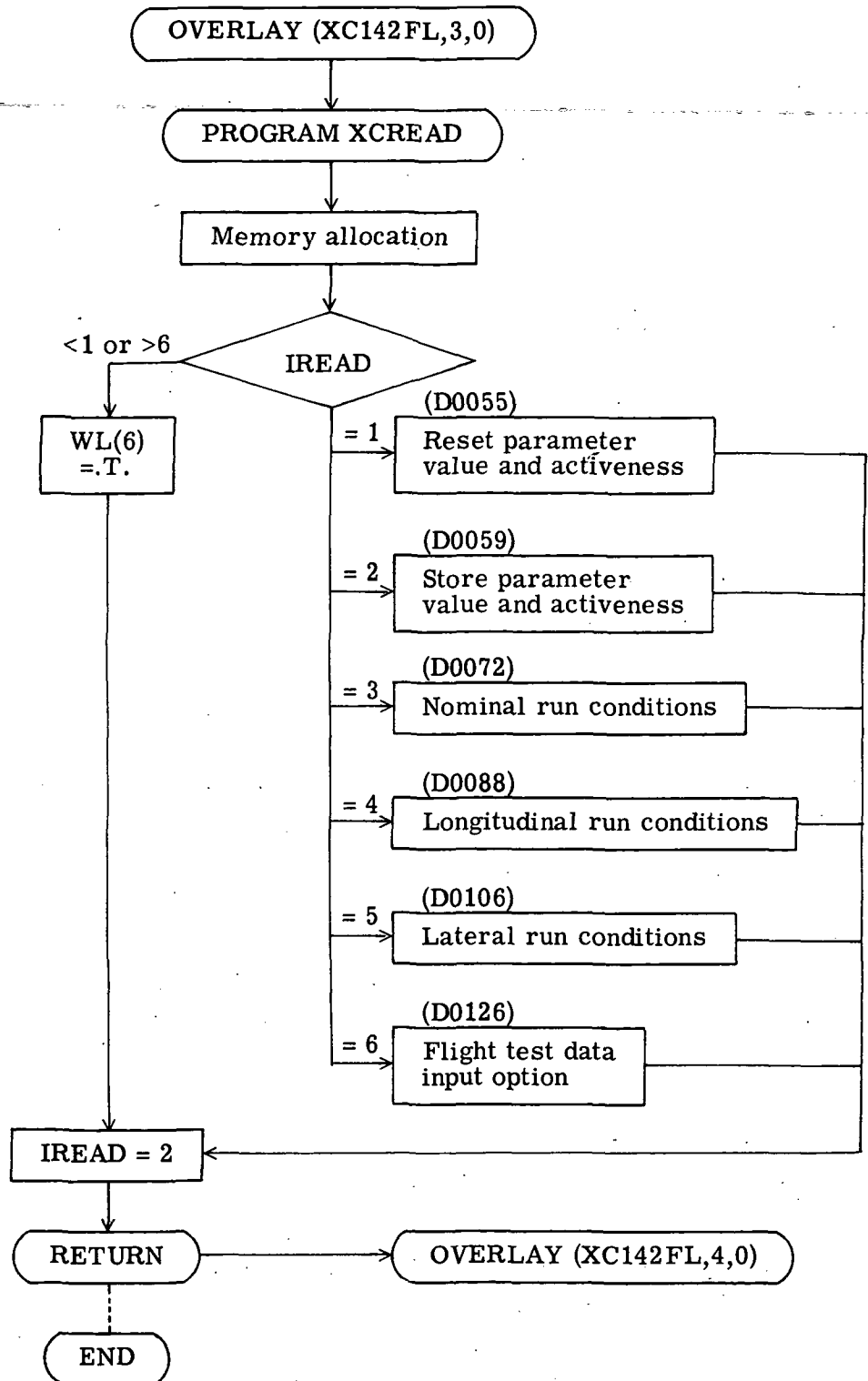
OVERLAY (XC142FL,3,0).- The read overlay, level (3,0), is loaded when the READ mode is selected on the program control console. The primary overlay, level (4,0), is automatically loaded upon completion of level (3,0). The integer IREAD preset in level (4,0) selects one of the six options in the READ overlay, one option being to input flight test data.

The flight test data input option uses a tape that was made by altering the original time records of all runs so that monotonically increasing time serves as the tape index key. Another aspect of the tape is that the time interval between consecutive points is constant for a given run, but does vary from run to run. The analyst can readily determine TS, TT, and NOPTS (tape starting time, tape time interval, and number of points, respectively) from the tape printout, but must consider frequencies involved to determine INC (sample rate of flight data tape). A major factor in determining INC is that DELX (program time interval of flight data, where  $DELX = TT \cdot INC$ ) must be an integral multiple of DT (program integration step size).

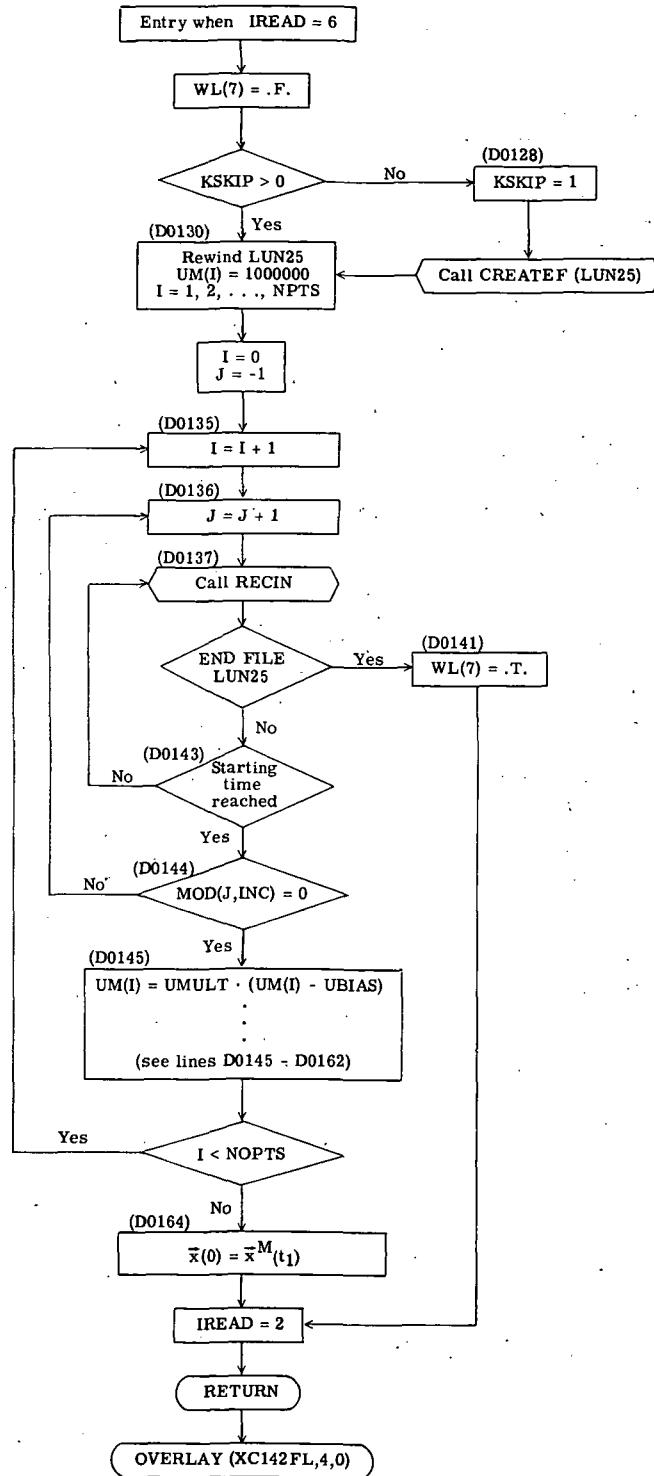
This option also provides the analyst with the opportunity to use biases and multipliers to eliminate certain apparent anomalies in the flight test data. An example of this usage is the putting in of control input trim conditions as biases.

To input flight test data, the determined values for TS, TT, NOPTS, INC, and any multipliers and/or biases must be entered into the computer. Then IREAD is changed to 6 and the READ switch is depressed. Input of flight test data is completed when the READ mode light comes on; if WL(7) is also on, an error in entering these values is apparent. The bottom RELEASE switch is depressed to complete the return to level (4,0).

The flow chart of the flight test data input option follows the flow chart of overlay level (3,0).



# FLIGHT TEST DATA INPUT OPTION



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OVERLAY(XC142FL,3,0) D 0001
PROGRAM XCREAD D 0002
LOGICAL LDISI,LDISO,LOGIC,VARCHNG,WL(39),FSS(16) D 0003
DIMENSION FWA25(1025),AL(40),INTX(8),INTY(11) D 0004
COMMON /INTCOMM/ T,H,INT,NEQ,ISCHEME,DERINT(2,249) D 0005
COMMON /INTINTR/ INTERN(5,249) D 0006
COMMON /REALTIM/ ADC(32),DAC(64),LDISI(108),LDISO(196),NOPER,NHOLD D 0007
1,NRESET,NTERM,NPRINT,NREAD D 0008
COMMON /ALGOR/ NPAR,[PAR,INTP(30),IP,INTV(8),IV,INTA(11),IA,IA1,IA D 0009
12,PARAM(40),DPARAM(30),ALV(11),DVAR(8),DALG(11),ALG(40),IAC(40),IE D 0010
2VEN,WT(11,11),COM,L1,L2 D 0011
COMMON /COMM1/ IRR,IPL,ISL,TABLE(199),INTEG(99),LOGIC(20),NTAB,NIN D 0012
1T,NLOG,NADC,NDAC,NLDI,NLDO,NT,AXI,AYI,AZI,DRAD,RADD,PI,IR(2),NRN,N D 0013
2PTS,ISKIP,JSKIP,KSKIP,MF,TX,TY,TZ,AMX,AMY,AMZ,VARCHNG,ITYPE,IVARBU D 0014
3F(5),DELX,NOITSPS,PTSINV D 0015
COMMON /COMM2/ MAXPAGE,LABT,LABU,LABV,LABW,LABP,LABQ,LABR,LABTH,LA D 0016
1BPH,LABAX,LABAY,LABAZ,LABDA,LABDE,LABDR,FET25(17),LUN25,NAM25,I TRN D 0017
2MLT(7),IMULTA(7),INVSEN(7),IMULTB(7),INVWT(7) D 0018
COMMON /FLIGHT/ UM(201),VM(201),WM(201),PM(201),QM(201),RM(201),TH D 0019
1M(201),PHM(201),AXM(201),AYM(201),AZM(201),FDA(201),FDE(201),FDR(2 D 0020
201),FBT(201),FDB(201),FDELB(201),FPPER(201),FTPER(201),BETAT,ETA,E D 0021
3TAT,FCT(12),CTT,CT D 0022
EQUIVALENCE (LDISO(61),WL(1)), (LDISI(33),FSS(1)), (AL(1),UO), (AL D 0023
1(5),THEO), (AL(6),PHIO), (AL(7),WO), (AL(12),QO), (AL(18),VO), (AL D 0024
2(25),PO), (AL(33),RO), (TABLE(1),AL(1)), (TABLE(65),UMULT), (TABLE D 0025
3(66),VMULT), (TABLE(67),WMULT), (TABLE(68),PMULT), (TABLE(69),QMUL D 0026
4T), (TABLE(70),RMULT), (TABLE(71),THMULT), (TABLE(72),PHMULT), (TA D 0027
5BLE(73),AXMULT), (TABLE(74),AYMULT), (TABLE(75),AZMULT), (TABLE(76 D 0028
6),DAMULT), (TABLE(77),DEMULT), (TABLE(78),DRMULT), (TABLE(79),UBIA D 0029
7S), (TABLE(80),VBIAS), (TABLE(81),WBIAS), (TABLE(82),PBIAS), (TABL D 0030
8E(83),QBIAS), (TABLE(84),RBIAS), (TABLE(85),THBIAS), (TABLE(86),PH D 0031
9BIAS), (TABLE(87),AXBIAS), (TABLE(88),AYBIAS), (TABLE(89),AZBIAS), D 0032
$ (TABLE(90),DABIAS), (TABLE(91),DEBIAS), (TABLE(92),DRBIAS), (TABL D 0033
$E(120),AIXZ), (TABLE(123),RHO), (TABLE(124),S), (TABLE(130),DT), ( D 0034
$TABLE(131),TT), (TABLE(132),TS), (TABLE(133),TIMF), (TABLE(171),UC D 0035
$RTBI), (TABLE(175),CTB), (TABLE(176),CTBT), (TABLE(178),CAPDT), (T D 0036
$ABLE(179),ELBAR), (TABLE(180),ELTP), (TABLE(181),RB), (TABLE(184), D 0037
$BTBIAS), (TABLE(185),PPERBI), (TABLE(186),TPERBI), (INTEG(51),INTY D 0038
$(1)), (INTEG(62),NOPTS), (INTEG(63),INC), (INTEG(66),IREAD), (INTE D 0039
$G(81),INTX(1)) D 0040
C IREAD=1 TO STORE ALG IN AL,ETC. D 0041
C IREAD=2 TO STORE AL IN ALG,ETC. (USES FSS(12)) D 0042
C IREAD=3 TO GET NOMINAL CONDITIONS D 0043
C IREAD=4 TO GET LONGITUDINAL CONDITIONS D 0044
C IREAD=5 TO GET LATERAL CONDITIONS D 0045
C IREAD=6 TO FILL FLIGHT DATA ARRAYS D 0046
C WL(6) INDICATES DEFAULT VALUE USED FOR IREAD D 0047
C WL(7) INDICATES ATTEMPT TO READ FLIGHT DATA BEYOND END FILE D 0048
L=IREAD D 0049
IREAD=2 D 0050
WL(6)=.F. D 0051
IF ((L.GE.1).AND.(L.LE.6)) GO TO 10 D 0052
WL(6)=.T. D 0053
RETURN D 0054
10 GO TO (20,40,60,80,110,140), L D 0055
20 DO 30 I=1,NPAR D 0056
AL(I)=ALG(I) D 0057
30 INTEG(I)=IAC(I) D 0058
RETURN D 0059
40 DO 50 I=1,NPAR D 0060
ALG(I)=TABLE(I) D 0061

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50	IAC(1)=INTEG(1)	D 0062
	IF (FSS(12)) RETURN	D 0063
	ALG(1)=UM(1)	D 0064
	ALG(18)=VM(1)	D 0065
	ALG(7)=WM(1)	D 0066
	ALG(25)=PM(1)	D 0067
	ALG(12)=QM(1)	D 0068
	ALG(33)=RM(1)	D 0069
	ALG(5)=THM(1)	D 0070
	ALG(6)=PHM(1)	D 0071
	RETURN	D 0072
60	AI XZ=8000.	D 0073
	RHO=.002186	D 0074
	S=534.4	D 0075
	DT=.05	D 0076
	TT=.05	D 0077
	TIMF=8.	D 0078
	CTB=.8423	D 0079
	CTBT=.573	D 0080
	CAPDT=8.	D 0081
	ELBAR=20.54	D 0082
	ELTP=32.09	D 0083
	RB=1.6	D 0084
	INC=2	D 0085
	DO 70 I=154,162	D 0086
70	TABLE(I)=0.	D 0087
	RETURN	D 0088
80	DO 90 I=1,11	D 0089
	IF (I.LT.9) INTX(I)=0	D 0090
90	INTY(I)=1	D 0091
	INTX(1)=INTX(3)=INTX(5)=INTX(7)=1	D 0092
	INTY(2)=INTY(4)=INTY(6)=INTY(8)=INTY(10)=0	D 0093
	D1=UO	D 0094
	D2=W0	D 0095
	D3=Q0	D 0096
	D4=THEO	D 0097
	DO 100 I=1,NPAR	D 0098
	AL(I)=0.	D 0099
	INTEG(I)=0	D 0100
	IF (I.LE.17) INTEG(I)=1	D 0101
100	CONTINUE	D 0102
	INTEG(6)=0	D 0103
	UO=D1	D 0104
	W0=D2	D 0105
	Q0=D3	D 0106
	THEO=D4	D 0107
	RETURN	D 0108
110	DO 120 I=1,11	D 0109
	IF (I.LT.9) INTX(I)=0	D 0110
120	INTY(I)=0	D 0111
	INTX(2)=INTX(4)=INTX(6)=INTX(8)=1	D 0112
	INTY(2)=INTY(4)=INTY(6)=INTY(8)=INTY(10)=1	D 0113
	D1=UO	D 0114
	D2=V0	D 0115
	D3=P0	D 0116
	D4=R0	D 0117
	D5=PHI0	D 0118
	DO 130 I=1,NPAR	D 0119
	AL(I)=0.	D 0120
	INTEG(I)=1	D 0121
	IF (I.LE.17) INTEG(I)=0	D 0122

130	CONTINUE	D 0123
	INTEG(6)=1	D 0124
	UO=D1	D 0125
	VO=D2	D 0126
	PO=D3	D 0127
	RO=D4	D 0128
	PHIO=D5	D 0129
	RETURN	D 0130
140	WL(7)=.F.	D 0131
	IF (KSKIP.GT.0) GO TO 150	D 0132
	KSKIP=1	D 0133
	CALL CREATEF (LUN25,FWA25,1025,FET25,NAM25)	D 0134
150	REWIND LUN25	D 0135
	DO 160 I=1,NPTS	D 0136
160	UM(I)=1.E6	D 0137
	I=0	D 0138
	J=-1	D 0139
170	I=I+1	D 0140
180	J=J+1	D 0141
190	CALL RECIN (LUN25,1,ICOUNT,X,UM(I),VM(I),WM(I),PM(I),QM(I),RM(I),T	D 0142
	1HM(I),PHM(I),AXM(I),AYM(I),AZM(I),FDA(I),FDE(I),FDR(I),FBT(I),FDB(	D 0143
	21),FDELB(I),FPPER(I),FTPER(I))	D 0144
	IF (ENDFILE LUN25) 200,210	D 0145
200	WL(7)=.T.	D 0146
	RETURN	D 0147
210	IF (X.LT.(TS-.001)) GO TO 190	D 0148
	IF (MOD(J,INC).NE.0) GO TO 180	D 0149
	UM(I)=UMULT*(UM(I)-UBIAS)	D 0150
	VM(I)=VMULT*(VM(I)-VBIAS)	D 0151
	WM(I)=WMULT*(WM(I)-WBIAS)	D 0152
	PM(I)=PMULT*(PM(I)-PBIAS)	D 0153
	QM(I)=QMULT*(QM(I)-QBIAS)	D 0154
	RM(I)=RMULT*(RM(I)-RBIAS)	D 0155
	THM(I)=THMULT*(THM(I)-THBIAS)	D 0156
	PHM(I)=PHMULT*(PHM(I)-PHBIAS)	D 0157
	AXM(I)=AXMULT*(AXM(I)-AXBIAS)	D 0158
	AYM(I)=AYMULT*(AYM(I)-AYBIAS)	D 0159
	AZM(I)=AZMULT*(AZM(I)-AZBIAS)	D 0160
	FDA(I)=DAMULT*(FDA(I)-DABIAS)	D 0161
	FDE(I)=DEMULT*(FDE(I)-DEBIAS)	D 0162
	FDR(I)=DRMULT*(FDR(I)-DRBIAS)	D 0163
	FBT(I)=FBT(I)-BTBIAS	D 0164
	IF (FDELB(I).LT.0.) FDELB(I)=0.	D 0165
	FPPER(I)=FPPER(I)-PPERBI	D 0166
	FTPER(I)=FTPER(I)-TPERBI	D 0167
	IF (I.LT.NOPTS) GO TO 170	D 0168
	I=UM(I)	D 0169
	UCRTBI=I	D 0170
	UO=UM(I)	D 0171
	VO=VM(I)	D 0172
	WO=WM(I)	D 0173
	PO=PM(I)	D 0174
	QO=QM(I)	D 0175
	RO=RM(I)	D 0176
	THEO=THM(I)	D 0177
	PHIO=PHM(I)	D 0178
	RETURN	D 0179
	END	D 0180

OVERLAY (XC142FL,4,0).- Overlay level (4,0) nominally operates in real time and is automatically loaded upon exiting levels (1,0), (2,0), and (3,0). Level (4,0) can cause the loading of levels (2,0) or (3,0) by selecting PRINT or READ mode, respectively, on the program control console. Level (4,0) contains the maximum likelihood estimation procedure (fig. 1) and CRT display loop.

The CRT display loop has been developed to present time history comparisons between flight data and calculated results. The performance index variables and control deflections are divided into four separate displays (each selectable from the program control console). The displays consist of multiple grids and annotated axes with

- (1) A (.) symbol to represent flight data points
- (2) Continuous vectors between calculated data points.

Displays available are selected as shown in the following table:

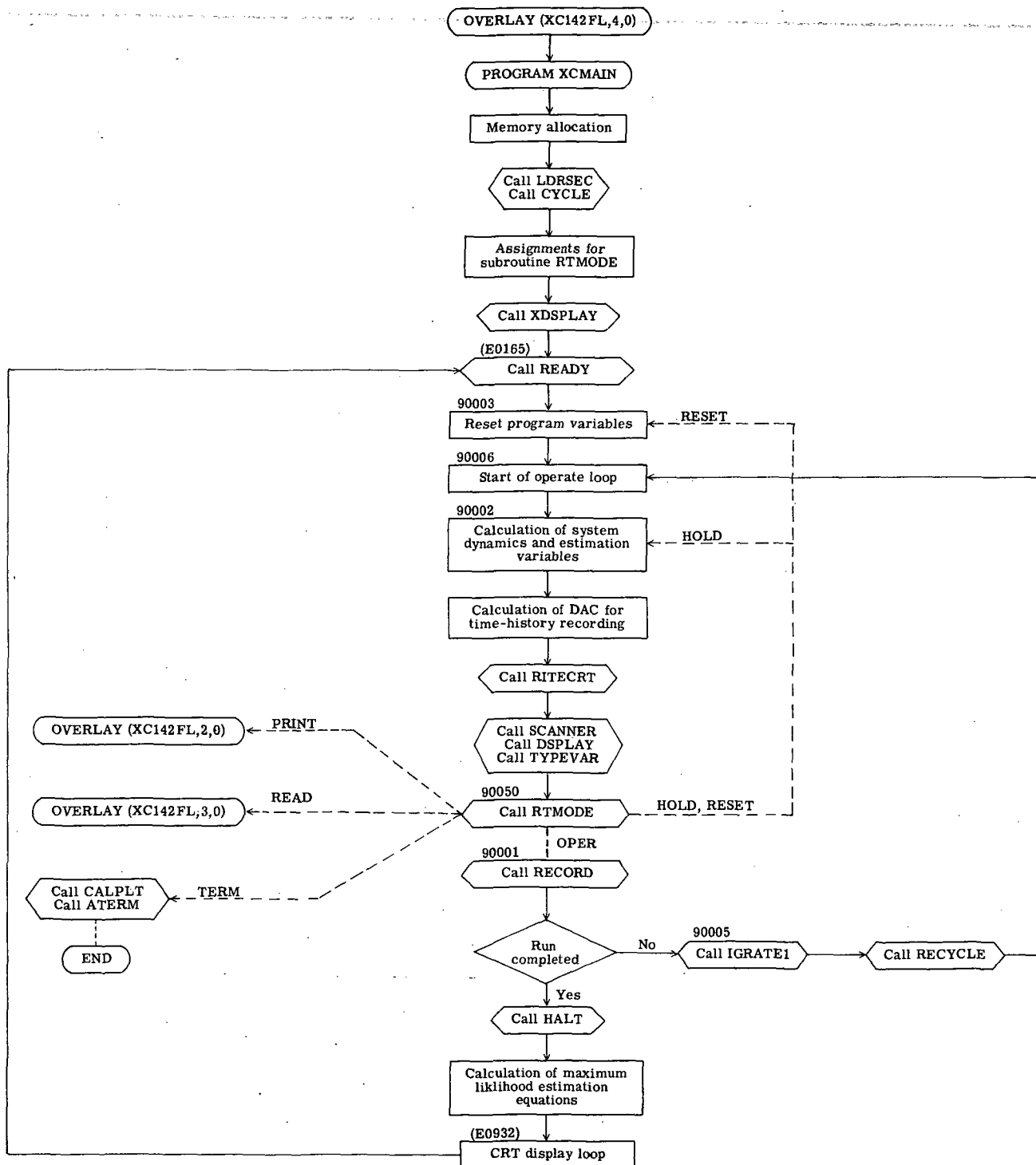
<u>Display</u>	<u>FSS(1)</u>	<u>FSS(7)</u>	<u>FSS(8)</u>
Longitudinal ( $u, w, q, \theta$ )	.F.	.F.	.F.
Lateral ( $p, r, v, \phi$ )	.F.	.T.	.F.
Accelerometer ( $a_{X,I}, a_{Y,I}, a_{Z,I}$ )	.T.	.F.	.F.
Controls ( $\delta_a, \delta_e, \delta_r$ (flight data only))	.F.	.F.	.T.

The CRT display loop is entered by any of the following methods:

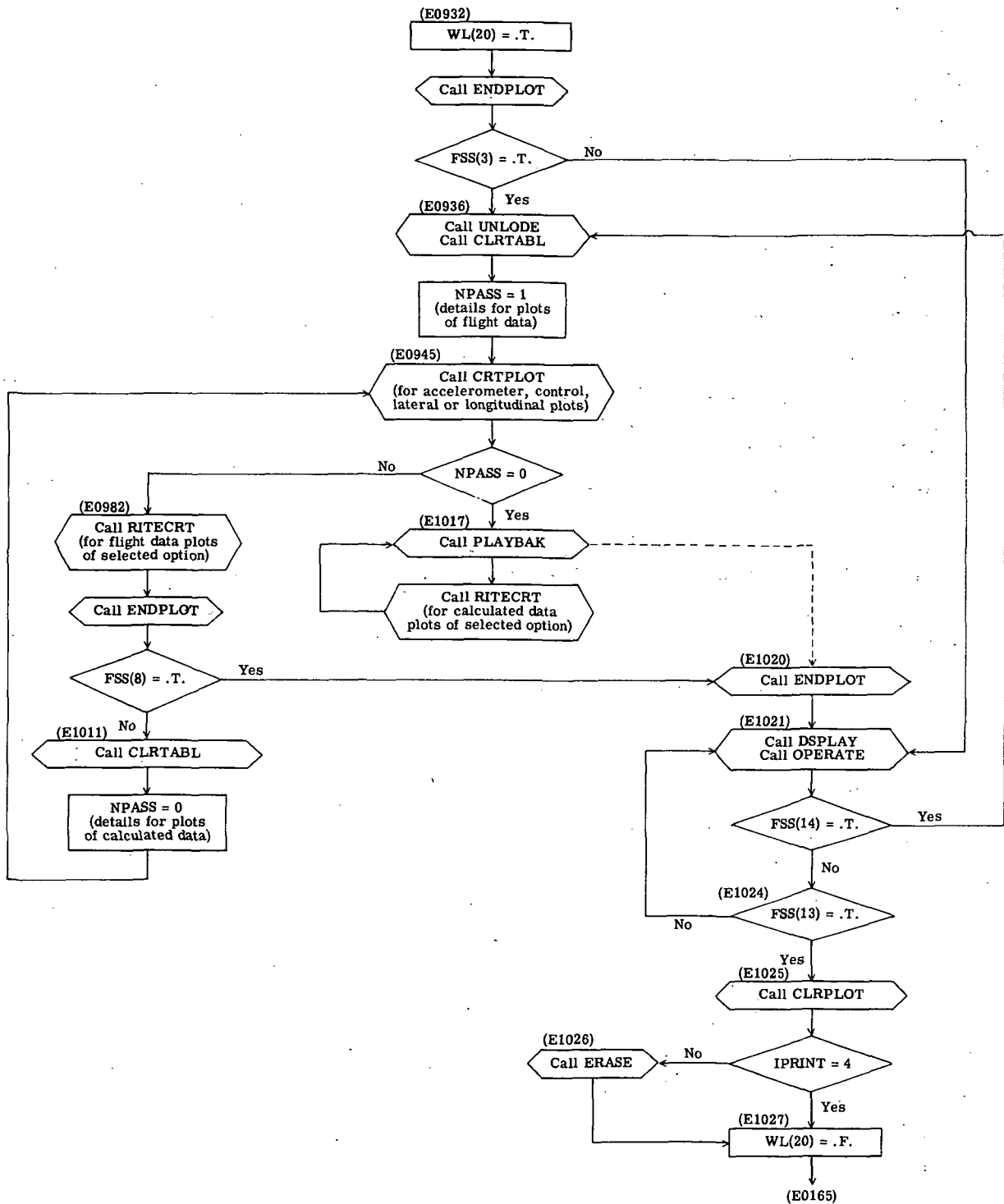
- (1) Depressing FSS(15) and then releasing when in the RESET mode
- (2) Depressing FSS(15) and then releasing when an operational error occurs
- (3) Automatically upon completion of any iteration
- (4) Automatically upon completion of pseudo data fill.

All four methods result in the program awaiting operator action, but method (4) first clears the existing display and plots the selected display. The operator action awaited is that of either requesting another display or exiting the CRT display loop. Requesting another display is accomplished by setting the appropriate FSS and depressing FSS(14) and then releasing. Exiting the CRT display loop is accomplished by depressing FSS(13).

The flow chart for the CRT display loop follows the flow chart for overlay level (4,0).



# CRT DISPLAY LOOP



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OVERLAY(XC142FL,4,0) E 0001
PROGRAM XCMAIN E 0002
REAL LIX,MIY,NIZ E 0003
LOGICAL FSS(16),LDISI,LDISO,LOGIC,VARCHNG,WL(39) E 0004
DIMENSION AL(40),DDELA(30),DDX(11),DPXTWDX(30),DX(11),INTX(8) E 0005
1,INTY(11),PX(11,30),PXD(6,40),PXTDX(30),PXTPX(30,30),PXTWT(3 E 0006
20,11),SD(11,11),XBAR(11),DRM(4),DRSD(4),G(8,8),PF(8,40),DEL E 0007
3A(40) E 0008
COMMON /INTCOMM/ T,H,INT,NEQ,ISCHEME,DERINT(2,249) E 0009
COMMON /INTINTR/ INTERN(5,249) E 0010
COMMON /REALTIM/ ADC(32),DAC(64),LDISI(108),LDISO(196),NOPER,NHOLD E 0011
1,NRESET,NTERM,NPRINT,NREAD E 0012
COMMON /ALGOR/ NPAR,IPAR,INTP(30),IP,INTV(8),IV,INTA(11),IA,IA1,IA E 0013
12,PARAM(40),DPARAM(30),ALV(11),DVAR(8),DALG(11),ALG(40),IAC(40),IE E 0014
2VEN,WT(11,11),COM,L1,L2 E 0015
COMMON /COMM1/ IRR,IPL,ISL,TABLE(199),INTEG(99),LOGIC(20),NTAB,NIN E 0016
1T,NLOG,NADC,NDAC,NLDI,NLDO,NT,AXI,AYI,AZI,DRAD,RADD,P1,IR(2),NRN,N E 0017
2PTS,ISKIP,JSKIP,KSKIP,MF,TX,TY,TZ,AMX,AMY,AMZ,VARCHNG,ITYPE,IVARBU E 0018
3F(5),DELX,NOITSPS,PTSINV E 0019
COMMON /COMM2/ MAXPAGE,LABT,LABU,LABV,LABW,LABP,LABQ,LABR,LABTH,LA E 0020
1BPH,LABAX,LABAY,LABAZ,LABDA,LABDE,LABDR,FET25(17),LUN25,NAM25,ITRN E 0021
2MLT(7),IMULTA(7),INVSEN(7),IMULTB(7),INVWT(7) E 0022
COMMON /FLIGHT/ UM(201),VM(201),WM(201),PM(201),QM(201),RM(201),TH E 0023
1M(201),PHM(201),AXM(201),AYM(201),AZM(201),FDA(201),FDE(201),FDR(2 E 0024
201),FBT(201),FDB(201),FDELB(201),FPPER(201),FTPER(201),BETAT,ETA,E E 0025
3TAT,FCT(12),CTT,CT E 0026
EQUIVALENCE (PF(1,3),F13), (PF(1,4),F14), (PF(2,19),F219), (PF(2,2 E 0027
10),F220), (PF(2,21),F221), (PF(2,22),F222), (PF(2,23),F223), (PF(2 E 0028
2,24),F224), (PF(3,9),F39), (PF(3,10),F310), (PF(3,11),F311), (PF(4 E 0029
3,26),F426), (PF(4,34),F434), (PF(4,35),F435), (PF(4,36),F436), (PF E 0030
4(4,37),F437), (PF(4,38),F438), (PF(4,39),F439), (PF(6,34),F634), ( E 0031
5G(2,1),G21), (G(2,2),G22), (G(2,3),G23), (G(2,4),G24), (G(2,6),G26 E 0032
6), (G(2,7),G27), (G(2,8),G28), (G(3,1),G31), (G(3,2),G32), (G(3,3) E 0033
7,G33), (G(3,4),G34), (G(3,5),G35), (G(3,7),G37), (G(3,8),G38), (LD E 0034
8ISO(61),WL(1)), (FSS(1),LDISI(33)), (DERINT(1,1),U), (DERINT(2,1), E 0035
9UDOT), (DERINT(1,2),V), (DERINT(2,2),VDOT), (DERINT(1,3),W), (DERI E 0036
$NT(2,3),WDOT), (DERINT(1,4),P), (DERINT(2,4),PDOT), (DERINT(1,5),Q E 0037
$), (DERINT(2,5),QDOT), (DERINT(1,6),R), (DERINT(2,6),RDOT), (DERIN E 0038
$T(1,7),THE), (DERINT(2,7),THEDOT), (DERINT(1,8),PHI), (DERINT(2,8) E 0039
$,PHIDOT), (DERINT(1,9),PSI), (DERINT(2,9),PSIDOT) E 0040
EQUIVALENCE (AL(1),UO), (AL(2),CXO), (AL(3),CXAL), (AL(4),CXO), (A E 0041
1L(5),THEO), (AL(6),PHIO), (AL(7),WO), (AL(8),CZO), (AL(9),CZAL), ( E 0042
2AL(10),CZO), (AL(11),CZDE), (AL(12),QO), (AL(13),CMO), (AL(14),CMA E 0043
3L), (AL(15),CMALD), (AL(16),CMQ), (AL(17),CMDE), (AL(18),VO), (AL( E 0044
419),CYO), (AL(20),CYB), (AL(21),CYBD), (AL(22),CYP), (AL(23),CYR), E 0045
5 (AL(24),CYDR), (AL(25),PO), (AL(26),CLO), (AL(27),CLB), (AL(28),C E 0046
6LBD), (AL(29),CLP), (AL(30),CLR), (AL(31),CLDR), (AL(32),CLDA), (A E 0047
7L(33),RO), (AL(34),CNO), (AL(35),CNB), (AL(36),CNBD), (AL(37),CNP) E 0048
8, (AL(38),CNR), (AL(39),CNRD), (AL(40),CNDA), (TABLE(1),AL(1)), (T E 0049
9ABLE(50),UMAX), (TABLE(51),VMAX), (TABLE(52),WMAX), (TABLE(53),PMA E 0050
$X), (TABLE(54),QMAX), (TABLE(55),RMAX), (TABLE(56),THMAX), (TABLE( E 0051
$57),PHMAX), (TABLE(58),AXMAX), (TABLE(59),AYMAX), (TABLE(60),AZMAX E 0052
$), (TABLE(62),DAMAX), (TABLE(63),DEMAX), (TABLE(64),DRMAX), (TABLE E 0053
$(65),UMULT), (TABLE(66),VMULT), (TABLE(67),WMULT), (TABLE(68),PMUL E 0054
$T), (TABLE(69),QMULT), (TABLE(70),RMULT), (TABLE(71),THMULT), (TAB E 0055
$LE(72),PHMULT), (TABLE(73),AXMULT), (TABLE(74),AYMULT), (TABLE(75) E 0056
$,AZMULT), (TABLE(76),DAMULT), (TABLE(77),DEMULT), (TABLE(78),DRMUL E 0057
$T), (TABLE(79),UBIAS) E 0058

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EQUIVALENCE (TABLE(80),VBIAS), (TABLE(81),WBIAS), (TABLE(82),PBIAS), E 0059
1), (TABLE(83),QBIAS), (TABLE(84),RBIAS), (TABLE(85),THBIAS), (TABL E 0060
2E(86),PHBIAS), (TABLE(87),AXBIAS), (TABLE(88),AYBIAS), (TABLE(89), E 0061
3AZBIAS), (TABLE(90),DABIAS), (TABLE(91),DEBIAS), (TABLE(92),DRBIAS E 0062
4), (TABLE(98),RUN), (TABLE(99),PASS), (TABLE(100),AJP), (TABLE(101 E 0063
5),DRM(1)), (TABLE(117),AIX), (TABLE(118),AIY), (TABLE(119),AIZ), ( E 0064
6TABLE(120),AIXZ), (TABLE(121),WEIGHT), (TABLE(122),GRAV), (TABLE(1 E 0065
723),RHO), (TABLE(124),S), (TABLE(125),B), (TABLE(126),CBAR), (TABL E 0066
8E(127),DEAMPL), (TABLE(128),DEFREQ), (TABLE(129),ALPHAT), (TABLE(1 E 0067
930),DT), (TABLE(131),TT), (TABLE(132),TS), (TABLE(133),TIMF), (TAB E 0068
$LE(154),XX), (TABLE(155),YX), (TABLE(156),ZX), (TABLE(157),XY), (T E 0069
$BLE(158),YY), (TABLE(159),ZY), (TABLE(160),XZ), (TABLE(161),YZ), ( E 0070
$(TABLE(162),ZZ), (TABLE(169),CMCON), (TABLE(170),DALMLT), (TABLE(1 E 0071
$71),UCRTBI), (TABLE(172),AIW), (TABLE(173),CTO), (TABLE(174),CTTO) E 0072
$, (TABLE(175),CTB), (TABLE(176),CTBT), (TABLE(177),D), (TABLE(178) E 0073
$,CAPDT), (TABLE(179),ELBAR), (TABLE(180),ELTP), (TABLE(181),RB), ( E 0074
$TABLE(182),PPER), (TABLE(183),TPER), (TABLE(184),BTBIAS), (TABLE(1 E 0075
$85),PPERB1), (TABLE(186),TPERBI), (TABLE(187),DET1), (TABLE(188),D E 0076
$SET2) E 0077
EQUIVALENCE (TABLE(191),DRSD(1)), (INTEG(51),INTY(1)), (INTEG(62), E 0078
1NOPTS), (INTEG(63),INC), (INTEG(64),IPRINT), (INTEG(65),NPLT), (1 E 0079
2NTEG(66),IREAD), (INTEG(67),KSCAN), (INTEG(81),INTX(1)) E 0080
C ARRAYS DIRECTLY INVOLVED IN ALGORITHM E 0081
C AL(1) CONTAINS VALUES FOR PARAMETERS (ALPHAS) E 0082
C INTEG(1) =1 FOR ACTIVE PARAMETER, =0 FOR INACTIVE PARAMETER E 0083
C INTX(1) =1 FOR ACTIVE STATE, =0 FOR INACTIVE STATES E 0084
C INTY(1) =1 FOR ACTIVE, =0 FOR INACTIVE ALG. VARIABLE E 0085
C INTP(1) ACTIVE PARAMETERS E 0086
C INTV(1) ACTIVE STATE VARIABLES E 0087
C INTA(1) ACTIVE ALGORITHM VARIABLES E 0088
C G(I,J) SENSITIVITY EQUATION MATRIX E 0089
C PF(I,J) EXPLICIT PARTIALS IN SENSITIVITY EQUATIONS E 0090
C PX(I,J) SENSITIVITY COEFFICIENTS E 0091
C PXD(I,J) DERIVATIVES OF PX E 0092
C DX(1) DIFFERENCE OF MEASURED AND CALCULATED STATE VARIABLES E 0093
C DDX(1) PACKED DX ARRAY E 0094
C XBAR(1) MEAN OF MEASUREMENT NOISE E 0095
C SD(I,J) STANDARD DEVIATION MATRIX E 0096
C WT(I,J) WEIGHT MATRIX E 0097
C PXTWT(I,J) INTERMEDIATE CALCULATION E 0098
C PXTDX(I,J) ACCUMULATED DPXTWDX FROM TIME=0 TO END OF ITERATION E 0099
C PXTPX(I,J) COVARIANCE MATRIX OF PARAMETERS E 0100
C DPXTWDX(1) RIGHT HAND SIDE OF PARAMETER CHANGE EQUATION E 0101
C DDELA(1) PACKED DELA ARRAY E 0102
C DELA(1) DELTA ALPHAS FOR PARAMETERS (UPDATES) E 0103
C WL(10) INDICATES NOPTS .GT. NPTS E 0104
C WL(11) INDICATES IP .GT. IPAR E 0105
C WL(12) INDICATES ERROR IN INITIALIZATION OF STATES E 0106
C WL(13) INDICATES ABS(THETA) .GT. 1.5 RADIANS E 0107
C WL(14) INDICATES U .LT. 5. FPS E 0108
C WL(15) INDICATES ABS(V) .GT. U E 0109
C WL(16) INDICATES ABS(ALF) .GT. 1.5 RADIANS E 0110
C WL(17) INDICATES ATTEMPTING TO USE UNFILLED FLIGHT DATA E 0111
C WL(18) INDICATES COVARIANCE MATRIX SINGULAR (DET1=0.) E 0112
C WL(19) INDICATES WEIGHT MATRIX SINGULAR (DET2=0.) E 0113
C WL(20) INDICATES IN CRT LOOP E 0114
C FSS(1)=.T. FOR ACCELERATIONS ON CRT E 0115
C FSS(2)=.T. FOR CALCOMP OF FLIGHT DATA ONLY E 0116
C FSS( 3)=.T. FOR PSEUDO-DATA-FILL E 0117
C FSS( 4)=.T. TEMPORARILY FOR VARIABLE DIMENSIONS E 0118
C FSS( 5)=.T. FOR OUTPUT LISTING E 0119

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C	FSS( 7)=.T. FOR LATERAL STATES ON CRT	E 0120
C	FSS( 8)=.T. FOR CONTROLS ON CRT	E 0121
C	FSS( 9)=.T. FOR PSEUDO FLIGHT FUNCTIONS	E 0122
C	FSS(10)=.T. TO SKIP UPDATE OF ALPHAS	E 0123
C	FSS(11)=.T. TO ENABLE TYPEWRITER	E 0124
C	FSS(12)=.T. TO RETAIN STATE I.C. S DURING STORING OF AL IN ALG	E 0125
C	FSS(13)=.T. TO EXIT CRT LOOP	E 0126
C	FSS(14)=.T. TEMP. FOR REPLOT	E 0127
C	FSS(15)=.T. TO ENTER CRT LOOP	E 0128
C	FSS(16)=.T. FOR TABLES ADDRESSING	E 0129
C	FSS(1,7,8)=.F. FOR LONGITUDINAL STATES ON CRT	E 0130
C	LOGIC(1)=.T. TO CALCULATE WEIGHT UPDATES	E 0131
C	LOGIC(2) =.T. FOR DIAGONALIZED WEIGHT MATRIX	E 0132
C	LOGIC(3)=.T. FOR MAIN PROP=FPPER(1)	E 0133
C	LOGIC(4)=.T. FOR TAIL = FTPER(1)	E 0134
C	LOGIC(5)=.T. FOR CTT=F(BETAT)	E 0135
C	LOGIC(6)=.T. FOR CZDE=CMDE*CMCON	E 0136
C	LOGIC(7)=.T. FOR LONGITUDINAL STATES=FLIGHT DATA	E 0137
C	LOGIC(8)=.T. FOR ALFT = ATAN(WO,UO)	E 0138
C	LOGIC(9)=.T. FOR TRIM CONDITIONS	E 0139
C	LOGIC(10)=.T. FOR AUTOMATIC TRIM	E 0140
C	LOGIC(11)=.T. FOR AUTOMATIC 2 PASS SYSTEM	E 0141
C	IPRINT=1 TO PRINT ICS	SET VALUE BEFORE PRINT E 0142
C	IPRINT=2 TO REWIND MF FILE	SET VALUE BEFORE PRINT E 0143
C	IPRINT=3 TO OBTAIN RANDOM NUMBERS	SET VALUE BEFORE PRINT E 0144
C	IPRINT=4 FOR CALCOMP PLOT (SET VALUE BEFORE EXITING CRT LOOP AND	E 0145
C	ENTERING PRINT - USES FSS(1,2,7,8,13,14))	E 0146
C	IPRINT=5 TO RETURN (ROUTES OUTPUT)	E 0147
C	IREAD=1 TO STORE ALG IN AL.ETC.	SET VALUE BEFORE READ E 0148
C	IREAD=2 TO STORE AL IN ALG.ETC.	E 0149
C	IREAD=3 TO GET NOMINAL CONDITIONS	SET VALUE BEFORE READ E 0150
C	IREAD=4 TO GET LONGITUDINAL CONDITIONS	SET VALUE BEFORE READ E 0151
C	IREAD=5 TO GET LATERAL CONDITIONS	SET VALUE BEFORE READ E 0152
C	IREAD=6 TO FILL FLIGHT DATA ARRAYS	SET VALUE BEFORE READ E 0153
	CALL LDRSEC	E 0154
	IF (.ISKIP.GT.0) GO TO 10	E 0155
	ISKIP=1	E 0156
	CALL CYCLE (90006S)	E 0157
	ASSIGN 90001 TO NOPER	E 0158
	ASSIGN 90002 TO NHOLD	E 0159
	ASSIGN 90003 TO NRESET	E 0160
	ASSIGN 90004 TO NTERM	E 0161
	ASSIGN 90014 TO NPRINT	E 0162
	ASSIGN 90015 TO NREAD	E 0163
	CALL XDSPLAY (LDISI,LDISO,VARCHNG,ITYPE,IVARBUF,FSS(16))	E 0164
10	CALL READY	E 0165
90003	CONTINUE	E 0166
	IF (NOPTS.LE.NPTS) GO TO 30	E 0167
	WL(10)=.T.	E 0168
	GO TO 740	E 0169
30	IF (.NOT.FSS(4)) GO TO 110	E 0170
	DO 40 I=1,IPAR	E 0171
	DPARAM(I)=10H	E 0172
40	INTP(I)=0	E 0173
	IP=0	E 0174
	DO 50 I=1,NPAR	E 0175
	IF (INTEG(I).EQ.0) GO TO 50	E 0176
	IP=IP+1	E 0177
	INTP(IP)=1	E 0178
	DPARAM(IP)=PARAM(I)	E 0179

50	CONTINUE	E 0180
	IF (IP.LE.IPAR) GO TO 60	E 0181
	WL(11)=.T.	E 0182
	GO TO 740	E 0183
60	DO 70 I=1,8	E 0184
	IF (INTY(I).EQ.0) GO TO 70	E 0185
	IF (INTX(I).EQ.1) GO TO 70	E 0186
	WL(12)=.T.	E 0187
	GO TO 740	E 0188
70	CONTINUE	E 0189
	IA1=0	E 0190
	IV=0	E 0191
	DO 80 I=1,8	E 0192
	DVAR(I)=10H	E 0193
	INTV(I)=0	E 0194
	IF (INTY(I).EQ.1) IA1=IA1+1	E 0195
	IF (INTX(I).EQ.0) GO TO 80	E 0196
	IV=IV+1	E 0197
	DVAR(IV)=ALV(I)	E 0198
	INTV(IV)=I	E 0199
80	CONTINUE	E 0200
	IA=0	E 0201
	DO 90 I=1,11	E 0202
	DALG(I)=10H	E 0203
	INTA(I)=0	E 0204
	IF (INTY(I).EQ.0) GO TO 90	E 0205
	IA=IA+1	E 0206
	DALG(IA)=ALV(I)	E 0207
	INTA(IA)=I	E 0208
90	CONTINUE	E 0209
	IA2=IA-IA1	E 0210
	ITRNMLT(2)=ITRNMLT(4)=IMULTA(3)=INVWT(2)=INVWT(3)=IA	E 0211
	ITRNMLT(3)=IMULTA(2)=INVSEN(2)=INVSEN(3)=IMULTB(2)=IMULTB(3)=IP	E 0212
	IF (.NOT.LOGIC(1)) GO TO 110	E 0213
	DO 100 I=1,IA	E 0214
	DO 100 J=1,IA	E 0215
	WT(I,J)=0.	E 0216
	IF (I.EQ.J) WT(I,J)=1.	E 0217
100	CONTINUE	E 0218
110	NEQ=9+IP*IV	E 0219
	IF (FSS(3)) NEQ=9	E 0220
	DO 120 I=1,IA	E 0221
	XBAR(I)=0.	E 0222
	DO 120 J=1,IA	E 0223
120	SD(I,J)=0.	E 0224
	DO 130 I=1,IP	E 0225
	PXTDX(I)=0.	E 0226
	DO 130 J=1,IP	E 0227
130	PXTPX(I,J)=0.	E 0228
	K=9	E 0229
	DO 230 I=1,IV	E 0230
	II=INTV(I)	E 0231
	DO 230 J=1,IP	E 0232
	JJ=INTP(J)	E 0233
	K=K+1	E 0234
	DERINT(1,K)=0.	E 0235
	GO TO (140,150,160,170,180,190,200,210), II	E 0236
140	IF (JJ.EQ.1) 220,230	E 0237
150	IF (JJ.EQ.18) 220,230	E 0238
160	IF (JJ.EQ.7) 220,230	E 0239
170	IF (JJ.EQ.25) 220,230	E 0240
180	IF (JJ.EQ.12) 220,230	E 0241
190	IF (JJ.EQ.33) 220,230	E 0242

200	IF (JJ.EQ.5) 220,230	E 0243
210	IF (JJ.EQ.6) 220,230	E 0244
220	DERINT(I,K)=1.	E 0245
230	CONTINUE	E 0246
	DO 240 J=1,NPAR	E 0247
	DELA(J)=0.	E 0248
	DO 240 I=1,8	E 0249
	IF (I.LT.7) PXD(I,J)=0.	E 0250
	IF (J.LT.9) G(I,J)=0.	E 0251
240	PF(I,J)=0.	E 0252
	G(8,4)=1.	E 0253
	INT=0	E 0254
	H=DT	E 0255
	VARCHNG=.FALSE.	E 0256
	T=0.	E 0257
	U=UO	E 0258
	V=VO	E 0259
	W=WO	E 0260
	P=PO	E 0261
	Q=QO	E 0262
	R=RO	E 0263
	THE=THEO	E 0264
	PHI=PHIO	E 0265
	PSI=0.	E 0266
	CYCL=2.*PI/DEFREQ	E 0267
	ALFT=ALPHAT*RADD	E 0268
	IF (LOGIC(8)) ALFT=ATAN2(WO,UO)	E 0269
	AJ=0.	E 0270
	ITS=-1	E 0271
	NOEL=0	E 0272
	DELX=TT*INC	E 0273
	NOITSPS=DELX/DT	E 0274
	TMAXX=DELX*(NOPTS-1)	E 0275
	PTSINV=1./NOPTS	E 0276
	GINV=1./GRAV	E 0277
	AMASINV=GRAV/WEIGHT	E 0278
	AIYINV=1./AIY	E 0279
	BTWO=.5*B	E 0280
	CBAR2=.5*CBAR	E 0281
	RHOS2=RHO*S*.5	E 0282
	A1=RHOS2*AMASINV	E 0283
	A2=A1*CBAR2	E 0284
	A3=A1*BTWO	E 0285
	A4=RHOS2*B	E 0286
	A5=A4*BTWO	E 0287
	CONIN=1./(AIX*AIZ-AIXZ**2)	E 0288
	A6=AIZ*CONIN	E 0289
	A7=(AIZ-AIX)*AIYINV	E 0290
	A8=RHOS2*CBAR*AIYINV	E 0291
	A9=A8*CBAR2	E 0292
	VDTCON=1./(1.-A3*CYBD)	E 0293
	PF21=A3*VDTCON	E 0294
	A9CMALD=A9*CMALD	E 0295
	B1=AIXZ*CONIN	E 0296
	B2=AIY-AIZ	E 0297
	B3=AIX-AIY	E 0298
	B4=AIXZ*AIYINV	E 0299
	B5=AIX*CONIN	E 0300
	PF41=A5*(A6*CLBD+B1*CNBD)	E 0301
	PF61=A5*(B1*CLBD+B5*CNBD)	E 0302
	B42=2.*B4	E 0303
	CIW=COS(AIW)	E 0304

	SIW=SIN(AIW)	E 0305
	CLDAP=CLDA*CIW-CNDA*SIW	E 0306
	CNDAP=CLDA*SIW+CNDA*CIW	E 0307
	CON=2.*RHO*D**4	E 0308
	CON1=2.*CON	E 0309
	CON2=ELBAR*CTB*CON	E 0310
	CON3=CIW*CON1	E 0311
	CON4=SIW*CON1	E 0312
	CON5=SIW*CON2	E 0313
	CON6=CIW*CON2	E 0314
	CON7=RB*CON1	E 0315
	CON8=RHO*CAPDT**4	E 0316
	CON9=ELTP*CON8	E 0317
	DCON=8.*D*D/PI	E 0318
90006	CONTINUE	E 0319
	ITS=ITS+1	E 0320
90002	CONTINUE	E 0321
90008	CONTINUE	E 0322
	K=9	E 0323
	DO 260 I=1,IV	E 0324
	DO 260 J=1,IP	E 0325
	K=K+1	E 0326
260	PX(I,J)=DERINT(I,K)	E 0327
	IF (.NOT.FSS(9)) GO TO 270	E 0328
	BETAT=DA=DB=DE=DELB=DR=PPER=TPER=0.	E 0329
	IF (T.LE.CYCL) DE=DEAMPL*SIN(DEFREQ*T)	E 0330
	GO TO 280	E 0331
270	FT=T	E 0332
	IS=FT/DELX	E 0333
	SS=FT/DELX-IS	E 0334
	IS1=IS+1	E 0335
	IS2=IS+2	E 0336
	IF (IS2.GT.NOPTS) IS2=NOPTS	E 0337
	SS1=1.-SS	E 0338
	DA=SS1*FDA(IS1)+SS*FDA(IS2)	E 0339
	DE=SS1*FDE(IS1)+SS*FDE(IS2)	E 0340
	DR=SS1*FDR(IS1)+SS*FDR(IS2)	E 0341
	BETAT=SS1*FBT(IS1)+SS*FBT(IS2)	E 0342
	DB=SS1*FDB(IS1)+SS*FDB(IS2)	E 0343
	DELB=SS1*FDELB(IS1)+SS*FDELB(IS2)	E 0344
	PPER=FPPER(1)	E 0345
	IF (.NOT.LOGIC(3)) PPER=SS1*FPPER(IS1)+SS*FPPER(IS2)	E 0346
	TPER=FTPER(1)	E 0347
	IF (.NOT.LOGIC(4)) TPER=SS1*FTPER(IS1)+SS*FTPER(IS2)	E 0348
	IF (.NOT.LOGIC(7)) GO TO 280	E 0349
	U=SS1*UM(IS1)+SS*UM(IS2)	E 0350
	W=SS1*WM(IS1)+SS*WM(IS2)	E 0351
	Q=SS1*QM(IS1)+SS*QM(IS2)	E 0352
	THE=SS1*THM(IS1)+SS*THM(IS2)	E 0353
280	CONTINUE	E 0354
	IF (ABS(THE).LT.1.5) GO TO 290	E 0355
	WL(13)=.T.	E 0356
	GO TO 740	E 0357
290	CONTINUE	E 0358
	IF (U.GT.5.) GO TO 300	E 0359
	WL(14)=.T.	E 0360
	GO TO 740	E 0361
300	CONTINUE	E 0362
	IF (ABS(V).LT.U) GO TO 310	E 0363
	WL(15)=.T.	E 0364
	GO TO 740	E 0365

310	UINV=1./U	E 0366
	ALF=ATAN2(W,U)-ALFT	E 0367
	IF (ABS(ALF).LT.1.5) GO TO 320	E 0368
	WL(16)=.T.	E 0369
	GO TO 740	E 0370
320	U2=U*U	E 0371
	V2=V*V	E 0372
	W2=W*W	E 0373
	VR2=U2+V2+W2	E 0374
	VR=SQRT(VR2)	E 0375
	VRINV=1./VR	E 0376
	BET=ASIN(V*VRINV)	E 0377
	ETA=1232.*PPER/60.	E 0378
	ETAT=40.*TPER	E 0379
	CT=CT0+CTB*DELB	E 0380
	IF (.NOT.LOGIC(5)) GO TO 330	E 0381
	FBET=ABS(BETAT*DRAD)	E 0382
	IF (FBET.GT.22.) FBET=22.	E 0383
	IS=FBET*.5	E 0384
	SS=FBET*.5-IS	E 0385
	TDUM=(1.-SS)*FCT(IS+1)+SS*FCT(IS+2)	E 0386
	IF (BETAT.LT.0.) TDUM=-TDUM	E 0387
	CTT=TDUM+CTT0	E 0388
	GO TO 340	E 0389
330	CONTINUE	E 0390
	CTT=CTBT*BETAT+CTT0	E 0391
340	CONTINUE	E 0392
	TEMP=ETA**2	E 0393
	TEMP1=CT*TEMP	E 0394
	TEMP2=DB*TEMP	E 0395
	TEMP3=ETAT**2*CTT	E 0396
	TX=CON3*TEMP1	E 0397
	TZ=-CON4*TEMP1-CON8*TEMP3	E 0398
	AMX=CON5*TEMP2	E 0399
	AMY=-CON7*TEMP1-CON9*TEMP3	E 0400
	AMZ=CON6*TEMP2	E 0401
	VSS2=DCON*TEMP1	E 0402
	VSS=SQRT(VSS2)	E 0403
	VSR=VSS+VR	E 0404
	VSRVR=VSR*VRINV	E 0405
	VSR2=VSR**2	E 0406
	STHE=SIN(THET)	E 0407
	CTHE=COS(THET)	E 0408
	SPHI=SIN(PHI)	E 0409
	CPHI=COS(PHI)	E 0410
	GCTHE=GRAV*CTHE	E 0411
	GSTHE=GRAV*STHE	E 0412
	TTHE=TAN(THET)	E 0413
	TXM=AMASINV*TX	E 0414
	TYM=AMASINV*TY	E 0415
	TZM=AMASINV*TZ	E 0416
	AMYIY=AIYINV*AMY	E 0417
	A1U=A1*U	E 0418
	A1V=A1*V	E 0419
	A1W=A1*W	E 0420
	A4U=A4*U	E 0421
	A4V=A4*V	E 0422
	A4W=A4*W	E 0423
	A8U=A8*U	E 0424
	A8V=A8*V	E 0425
	A8W=A8*W	E 0426

A1VR=A1*VR	E 0427
A2VR=A2*VR	E 0428
A3VR=A3*VR	E 0429
A4VR=A4*VR	E 0430
A5VR=A5*VR	E 0431
A9VR=A9*VR	E 0432
A1VR2=A1*VR2	E 0433
A4VR2=A4*VR2	E 0434
A4VSR2=A4*VSR2	E 0435
A8VR2=A8*VR2	E 0436
B2VR=BTW0*VRINV	E 0437
PF22=PF21*VR	E 0438
PF42=A6*A5VR	E 0439
PF43=A4VSR2*DA	E 0440
PF44=B1*A5VR	E 0441
PF62=B5*A5VR	E 0442
CBAR2VR=CBAR2*VRINV	E 0443
P2=P*P	E 0444
Q2=Q*Q	E 0445
R2=R*R	E 0446
PQ=P*Q	E 0447
PR=P*R	E 0448
QR=Q*R	E 0449
Q1=Q*A1XZ	E 0450
CX1=CX0+ALF*CXAL	E 0451
CX2=CXQ*Q*CBAR2VR	E 0452
CY1=CY0+BET*CYB+DR*CYDR	E 0453
CY2=B2VR*(P*CYP+R*CYR)	E 0454
CZ1=CZ0+ALF*CZAL+DE*CZDE	E 0455
CZ2=CZQ*Q*CBAR2VR	E 0456
FXM=A1VR2*(CX1+CX2)	E 0457
FYM=A1VR2*(CY1+CY2)	E 0458
FZM=A1VR2*(CZ1+CZ2)	E 0459
UDP=R*V-Q*W-GSTHE	E 0460
VDP=P*W-R*U+GCTHE*SPHI	E 0461
WDP=Q*U-P*V+GCTHE*CPHI	E 0462
UDOT=UDP+FXM+TXM	E 0463
VDOT=VDTCON*(VDP+FYM+TYM)	E 0464
WDOT=WDP+FZM+TZM	E 0465
IF (INTX(1).EQ.0) UDOT=0.	E 0466
IF (INTX(2).EQ.0) VDOT=0.	E 0467
IF (INTX(3).EQ.0) WDOT=0.	E 0468
IF (,NOT,LOGIC(9)) GO TO 350	E 0469
CALL HALT	E 0470
CX1=CX1-CX0	E 0471
CY1=CY1-CY0	E 0472
CZ1=CZ1-CZ0	E 0473
TMP1=1./A1VR2	E 0474
CX0=CX0-UDOT*TMP1	E 0475
CY0=CY0-VDOT*TMP1/VDTCON	E 0476
CZ0=CZ0-WDOT*TMP1	E 0477
UDOT=0.	E 0478
VDOT=0.	E 0479
WDOT=0.	E 0480
CX1=CX1+CX0	E 0481
CY1=CY1+CY0	E 0482
CZ1=CZ1+CZ0	E 0483

350	CONTINUE	E 0484
	ALFD=WDOT*UINV	E 0485
	BETD=VDOT*VRINV	E 0486
	BDB2VR=BETD*B2VR	E 0487
	CL1=CLO+BET*CLB+DR*CLDR	E 0488
	CL2=(BETD*CLBD+P*CLP+R*CLR)*B2VR	E 0489
	CL3=DA*CLDAP	E 0490
	CM1=CMO+ALF*CMAL+DE*CMDE	E 0491
	CM2=(ALFD*CMALD+Q*CMQ)*CBAR2VR	E 0492
	CN1=CNO+BET*CNB+DR*CNDR	E 0493
	CN2=(BETD*CNBD+P*CNP+R*CNR)*B2VR	E 0494
	CN3=DA*CNDAP	E 0495
	LIX=A4VR2*(CL1+CL2)+A4VSR2*CL3	E 0496
	MIY=A8VR2*(CM1+CM2)	E 0497
	NIZ=A4VR2*(CN1+CN2)-A4VSR2*CN3	E 0498
	F4P=Q*(B2*R+P*AIXZ)+LIX+AMX	E 0499
	F6P=Q*(B3*P-R*AIXZ)+NIZ+AMZ	E 0500
	PDOT=A6*F4P+B1*F6P	E 0501
	QDOT=A7*PR+B4*(R2-P2)+MIY+AMYIY	E 0502
	RDOT=B1*F4P+B5*F6P	E 0503
	IF (INTX(4).EQ.0) PDOT=0.	E 0504
	IF (INTX(5).EQ.0) QDOT=0.	E 0505
	IF (INTX(6).EQ.0) RDOT=0.	E 0506
	IF (.NOT.LOGIC(9)) GO TO 360	E 0507
	LOGIC(9)=.F.	E 0508
	CL1=CL1-CLO	E 0509
	CM1=CM1-CMO	E 0510
	CN1=CN1-CNO	E 0511
	TMP4=1./A4VR2	E 0512
	CLO=CLO-F4P*TMP4	E 0513
	CMO=CMO-QDOT/ABVR2	E 0514
	CNO=CNO-F6P*TMP4	E 0515
	PDOT=0.	E 0516
	QDOT=0.	E 0517
	RDOT=0.	E 0518
	CL1=CL1+CLO	E 0519
	CM1=CM1+CMO	E 0520
	CN1=CN1+CNO	E 0521
	CALL READY	E 0522
360	CONTINUE	E 0523
	AXCG=GINV*(UDOT-UDP)	E 0524
	AYCG=GINV*(VDOT-VDP)	E 0525
	AZCG=GINV*(WDOT-WDP)	E 0526
	AXI=AXCG+GINV*(-(R2+Q2)*XX+(PQ-RDOT)*YX+(PR+QDOT)*ZX)	E 0527
	AYI=AYCG+GINV*((PQ+RDOT)*XY-(P2+R2)*YY+(QR-PDOT)*ZY)	E 0528
	AZI=AZCG+GINV*((PR-QDOT)*XZ+(QR+PDOT)*YZ-(P2+Q2)*ZZ)	E 0529
	THEDOT=Q*CPHI-R*SPHI	E 0530
	PSIDOT=(Q*SPHI+R*CPHI)/CTHE	E 0531
	PHIDOT=P+PSIDOT*STHE	E 0532
	IF (INTX(7).EQ.0) THEDOT=0.	E 0533
	IF (INTX(8).EQ.0) PHIDOT=0.	E 0534
	IF (.NOT.FSS(3)) GO TO 370	E 0535
	IF (MOD(ITS,NOITSPS).NE.0) GO TO 530	E 0536
	IF (.NOT.LDISI(18)) NOEL=NOEL+1	E 0537
	UM(NOEL)=U	E 0538
	VM(NOEL)=V	E 0539
	WM(NOEL)=W	E 0540
	PM(NOEL)=P	E 0541
	QM(NOEL)=Q	E 0542
	RM(NOEL)=R	E 0543
	THM(NOEL)=THE	E 0544
	PHM(NOEL)=PHI	E 0545

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AXM(NOEL)=AXI	E 0546
AYM(NOEL)=AYI	E 0547
AZM(NOEL)=AZI	E 0548
FDA(NOEL)=DA	E 0549
FDE(NOEL)=DE	E 0550
FDR(NOEL)=DR	E 0551
FBT(NOEL)=BETAT	E 0552
FDB(NOEL)=DB	E 0553
FDELR(NOEL)=DELB	E 0554
FPPER(NOEL)=PPER	E 0555
FTPER(NOEL)=TPER	E 0556
GO TO 530	E 0557
CONTINUE	E 0558
PF(1,2)=A1VR2	E 0559
PF(1,3)=A1VR2*ALF	E 0560
PF(1,4)=A2VR*Q	E 0561
PF(2,19)=VDTCON*A1VR2	E 0562
PF(2,20)=F219*BET	E 0563
PF(2,21)=PF21*VDOT	E 0564
PF(2,22)=PF22*P	E 0565
PF(2,23)=PF22*R	E 0566
PF(2,24)=F219*DR	E 0567
PF(3,8)=A1VR2	E 0568
PF(3,9)=F13	E 0569
PF(3,10)=F14	E 0570
PF(3,11)=A1VR2*DE	E 0571
PF(4,19)=F219*PF41	E 0572
PF(4,20)=F220*PF41	E 0573
PF(4,21)=F221*PF41	E 0574
PF(4,22)=F222*PF41	E 0575
PF(4,23)=F223*PF41	E 0576
PF(4,24)=F224*PF41	E 0577
PF(4,26)=A6*A4VR2	E 0578
PF(4,27)=F426*BET	E 0579
PF(4,28)=PF42*BETD	E 0580
PF(4,29)=PF42*P	E 0581
PF(4,30)=PF42*R	E 0582
PF(4,31)=F426*DR	E 0583
PF(4,32)=PF43*(A6*CIW-B1*SIW)	E 0584
PF(4,34)=B1*A4VR2	E 0585
PF(4,35)=F434*BET	E 0586
PF(4,36)=PF44*BETD	E 0587
PF(4,37)=PF44*P	E 0588
PF(4,38)=PF44*R	E 0589
PF(4,39)=F434*DR	E 0590
PF(4,40)=-PF43*(B1*CIW+A6*SIW)	E 0591
PF(5,8)=A1VR2*A9CMALD	E 0592
PF(5,9)=F39*A9CMALD	E 0593
PF(5,10)=F310*A9CMALD	E 0594
PF(5,11)=F311*A9CMALD	E 0595
PF(5,13)=A8VR2	E 0596
PF(5,14)=A8VR2*ALF	E 0597
PF(5,15)=A9VR*ALFD	E 0598
PF(5,16)=A9VR*Q	E 0599
PF(5,17)=A8VR2*DE	E 0600
PF(6,19)=F219*PF61	E 0601
PF(6,20)=F220*PF61	E 0602
PF(6,21)=F221*PF61	E 0603
PF(6,22)=F222*PF61	E 0604
PF(6,23)=F223*PF61	E 0605
PF(6,24)=F224*PF61	E 0606

PF(6,26)=F434	E 0607
PF(6,27)=F435	E 0608
PF(6,28)=F436	E 0609
PF(6,29)=F437	E 0610
PF(6,30)=F438	E 0611
PF(6,31)=F439	E 0612
PF(6,32)=PF43*(B1*CIW-B5*SIW)	E 0613
PF(6,34)=B5*A4VR2	E 0614
PF(6,35)=F634*BET	E 0615
PF(6,36)=PF62*BETO	E 0616
PF(6,37)=PF62*P	E 0617
PF(6,38)=PF62*R	E 0618
PF(6,39)=F634*DR	E 0619
PF(6,40)=-PF43*(B5*CIW+B1*SIW)	E 0620
G1P=2.*CX1+CX2	E 0621
G2P=2.*CY1+CY2-BET*CYB	E 0622
G3P=2.*CZ1+CZ2	E 0623
G4P=2.*(CL1+CL3*VSRVR)+CL2-BET*CLB-BDB2VR*CLBD	E 0624
G5P=2.*CM1+CM2	E 0625
G6P=2.*(CN1-CN3*VSRVR)+CN2-BET*CNB-BDB2VR*CNBD	E 0626
G(1,1)=A1U*G1P-A1W*CXAL	E 0627
G(1,2)=A1V*G1P+R	E 0628
G(1,3)=A1W*G1P+A1U*CXAL-Q	E 0629
G(1,5)=A2VR*CXQ-W	E 0630
G(1,6)=V	E 0631
G(1,7)=-GCTHE	E 0632
G(2,1)=VDTCON*(A1U*G2P-R)	E 0633
G(2,2)=VDTCON*(A1V*G2P+A1VR*CYB)	E 0634
G(2,3)=VDTCON*(A1W*G2P+P)	E 0635
G(2,4)=VDTCON*(A3VR*CYP+W)	E 0636
G(2,6)=VDTCON*(A3VR*CYR-U)	E 0637
G(2,7)=-GSTHE*SPHI*VDTCON	E 0638
G(2,8)=GCTHE*CPHI*VDTCON	E 0639
G(3,1)=A1U*G3P-A1W*CZAL+Q	E 0640
G(3,2)=A1V*G3P-P	E 0641
G(3,3)=A1W*G3P+A1U*CZAL	E 0642
G(3,4)=-V	E 0643
G(3,5)=A2VR*CZQ+U	E 0644
G(3,7)=-GSTHE*CPHI	E 0645
G(3,8)=-GCTHE*SPHI	E 0646
G41=A4U*G4P	E 0647
G42=A4V*G4P+A4VR*CLB	E 0648
G43=A4W*G4P	E 0649
G44=QI+A5VR*CLP	E 0650
G45=R*B2+P*A1XZ	E 0651
G46=Q*B2+A5VR*CLR	E 0652
G61=A4U*G6P	E 0653
G62=A4V*G6P+A4VR*CNB	E 0654
G63=A4W*G6P	E 0655
G64=Q*B3+A5VR*CNP	E 0656
G65=P*B3-R*A1XZ	E 0657
G66=A5VR*CNR-QI	E 0658
G(4,1)=A6*G41+B1*G61+PF41*G21	E 0659
G(4,2)=A6*G42+B1*G62+PF41*G22	E 0660
G(4,3)=A6*G43+B1*G63+PF41*G23	E 0661
G(4,4)=A6*G44+B1*G64+PF41*G24	E 0662
G(4,5)=A6*G45+B1*G65	E 0663
G(4,6)=A6*G46+B1*G66+PF41*G26	E 0664

	G(4,7)=PF41*G27	E 0665
	G(4,8)=PF41*G28	E 0666
	G(5,1)=ABU*G5P-ABW*CMAL+A9CMALD*(G31-ALFD)	E 0667
	G(5,2)=ABV*G5P+A9CMALD*G32	E 0668
	G(5,3)=ABW*G5P+A9CMALD*G33+ABU*CMAL	E 0669
	G(5,4)=R*A7-B42*P+A9CMALD*G34	E 0670
	G(5,5)=A9VR*CMQ+A9CMALD*G35	E 0671
	G(5,6)=P*A7+B42*R	E 0672
	G(5,7)=A9CMALD*G37	E 0673
	G(5,8)=A9CMALD*G38	E 0674
	G(6,1)=B1*G41+B5*G61+PF61*G21	E 0675
	G(6,2)=B1*G42+B5*G62+PF61*G22	E 0676
	G(6,3)=B1*G43+B5*G63+PF61*G23	E 0677
	G(6,4)=B1*G44+B5*G64+PF61*G24	E 0678
	G(6,5)=B1*G45+B5*G65	E 0679
	G(6,6)=B1*G46+B5*G66+PF61*G26	E 0680
	G(6,7)=PF61*G27	E 0681
	G(6,8)=PF61*G28	E 0682
	G(7,5)=CPHI	E 0683
	G(7,6)=-SPHI	E 0684
	G(7,8)=-PSIDOT*CTHE	E 0685
	G(8,5)=SPHI*TTHE	E 0686
	G(8,6)=CPHI*TTHE	E 0687
	G(8,7)=PSIDOT/CTHE	E 0688
	G(8,8)=THEDOT*TTHE	E 0689
	L=9	E 0690
	DO 390 I=1,IV	E 0691
	II=INTV(I)	E 0692
	DO 390 J=1,IP	E 0693
	L=L+1	E 0694
	JJ=INTP(J)	E 0695
	GPX=0.	E 0696
	DO 380 K=1,IV	E 0697
	KK=INTV(K)	E 0698
380	GPX=GPX+G(II,KK)*PX(K,J)	E 0699
	DERINT(2,L)=GPX+PF(II,JJ)	E 0700
	IF (II,LT,7) PXD(II,JJ)=DERINT(2,L)	E 0701
390	CONTINUE	E 0702
	IF (IA1.EQ.1A) GO TO 450	E 0703
	G(1,1)=0.	E 0704
	G(1,2)=-R	E 0705
	G(1,3)=Q	E 0706
	G(1,4)=YX*Q+ZX*R	E 0707
	G(1,5)=-2.*XX*Q+YX*P+W	E 0708
	G(1,6)=-2.*XX*R+ZX*P-V	E 0709
	G(1,7)=GCTHE	E 0710
	G(2,1)=R	E 0711
	G(2,2)=0.	E 0712
	G(2,3)=-P	E 0713
	G(2,4)=-W+XY*Q-2.*YY*P	E 0714
	G(2,5)=XY*P+ZY*R	E 0715
	G(2,6)=U-2.*YY*R+ZY*Q	E 0716
	G(2,7)=GSTHE*SPHI	E 0717
	G(2,8)=-GCTHE*CPHI	E 0718
	G(3,1)=-Q	E 0719
	G(3,2)=P	E 0720
	G(3,3)=0.	E 0721
	G(3,4)=V+XZ*R-2.*ZZ*P	E 0722
	G(3,5)=-U+YZ*R-2.*ZZ*Q	E 0723
	G(3,6)=XZ*P+YZ*Q	E 0724
	G(3,7)=GSTHE*CPHI	E 0725
	G(3,8)=GCTHE*SPHI	E 0726

L=IV	E 0727
M=IA1	E 0728
DO 440 I=1,IA2	E 0729
L=L+1	E 0730
M=M+1	E 0731
II=INTA(M)-8	E 0732
DO 440 J=1,IP	E 0733
JJ=INTP(J)	E 0734
GPX=0.	E 0735
DO 400 K=1,IV	E 0736
KK=INTV(K)	E 0737
400 GPX=GPX+G(II,KK)*PX(K,J)	E 0738
GO TO (410,420,430), II	E 0739
410 PX(L,J)=(GPX+PXD(1,JJ)+ZX*PXD(5,JJ)-YX*PXD(6,JJ))*GINV	E 0740
GO TO 440	E 0741
420 PX(L,J)=(GPX+PXD(2,JJ)-ZY*PXD(4,JJ)+XY*PXD(6,JJ))*GINV	E 0742
GO TO 440	E 0743
430 PX(L,J)=(GPX+PXD(3,JJ)+YZ*PXD(4,JJ)-XZ*PXD(5,JJ))*GINV	E 0744
440 CONTINUE	E 0745
G(1,4)=G(2,5)=G(3,6)=0.	E 0746
450 CONTINUE	E 0747
IF (IA1.EQ.IV) GO TO 480	E 0748
J=0	E 0749
L=0	E 0750
DO 470 I=1,II	E 0751
IF (I.LE.8) J=J+INTX(I)	E 0752
IF (INTY(I).EQ.0) GO TO 470	E 0753
L=L+1	E 0754
IF (I.GT.8) J=J+1	E 0755
DO 460 K=1,IP	E 0756
460 PX(L,K)=PX(J,K)	E 0757
470 CONTINUE	E 0758
480 CONTINUE	E 0759
IF (MOD(ITS,NOITSPS).NE.0) GO TO 530	E 0760
IF (.NOT.LDISI(18)) NOEL=NOEL+1	E 0761
IF (UM(NOEL).LT.1.E5) GO TO 490	E 0762
WL(17)=.T.	E 0763
GO TO 740	E 0764
490 CONTINUE	E 0765
DX(1)=UM(NOEL)-U	E 0766
DX(2)=VM(NOEL)-V	E 0767
DX(3)=WM(NOEL)-W	E 0768
DX(4)=PM(NOEL)-P	E 0769
DX(5)=QM(NOEL)-Q	E 0770
DX(6)=RM(NOEL)-R	E 0771
DX(7)=THM(NOEL)-THE	E 0772
DX(8)=PHM(NOEL)-PHI	E 0773
DX(9)=AXM(NOEL)-AXI	E 0774
DX(10)=AYM(NOEL)-AYI	E 0775
DX(11)=AZM(NOEL)-AZI	E 0776
DO 500 I=1,IA	E 0777
II=INTA(I)	E 0778
DDX(I)=DX(II)	E 0779
AJ=AJ+DDX(I)**2	E 0780
500 XBAR(I)=XBAR(I)+DDX(I)*PTSINV	E 0781
DO 510 I=1,IA	E 0782
DO 510 J=1,IA	E 0783
510 SD(I,J)=SD(I,J)+DDX(I)*DDX(J)*PTSINV	E 0784
C PXTWT= (PX)T(WT)	E 0785
CALL MASCNT (ITRNMLT,PX,WT,PXTWT)	E 0786

C	DPXTWDX= (PXTWT)(DDX)	E 0787
	CALL MASCNT (IMULTA,PXTWT,DDX,DPXTWDX)	E 0788
	DO 520 I=1,IP	E 0789
	PXTDX(I)=PXTDX(I)+DPXTWDX(I)	E 0790
	DO 520 J=1,JP	E 0791
	DO 520 K=1,KA	E 0792
520	PXTPX(I,J)=PXTPX(I,J)+PXTWT(I,K)*PX(K,J)	E 0793
530	CONTINUE	E 0794
	TABLE(134)=T	E 0795
	TABLE(135)=U	E 0796
	TABLE(136)=V	E 0797
	TABLE(137)=W	E 0798
	TABLE(138)=P	E 0799
	TABLE(139)=Q	E 0800
	TABLE(140)=R	E 0801
	TABLE(141)=THE	E 0802
	TABLE(142)=PHI	E 0803
	TABLE(143)=PSI	E 0804
	TABLE(144)=UDOT	E 0805
	TABLE(145)=VDOT	E 0806
	TABLE(146)=WDOT	E 0807
	TABLE(147)=PDOT	E 0808
	TABLE(148)=QDOT	E 0809
	TABLE(149)=RDOT	E 0810
	TABLE(150)=THEDOT	E 0811
	TABLE(151)=PHIDOT	E 0812
	TABLE(152)=PSIDOT	E 0813
C	DACS FOR TIME HISTORY RECORDERS	E 0814
	DAC(1)=(U-UCRTBI)/UMAX	E 0815
	DAC(2)=V/VMAX	E 0816
	DAC(3)=W/WMAX	E 0817
	DAC(4)=P/PMAX	E 0818
	DAC(5)=Q/QMAX	E 0819
	DAC(6)=R/RMAX	E 0820
	DAC(7)=THE/THMAX	E 0821
	DAC(8)=PHI/PHMAX	E 0822
C	RITECRT PLOTS IN REAL TIME IF T .LE. TMAXX	E 0823
	IF (.NOT.FSS(3).AND.(T.LE.TMAXX)) CALL RITECRT (LDISI(17),.T.,MAXP	E 0824
	1AGE)	E 0825
	IF (LDISI(22)) CALL SCANNER (KSCAN)	E 0826
	CALL DISPLAY	E 0827
	IF (LDISI(17)) GO TO 90050	E 0828
	IF (VARCHNG.AND.FSS(11)) CALL TYPEVAR	E 0829
	IF (FSS(11).AND.LDISI(14)) CALL TYPEVAR	E 0830
	IF (FSS(15)) GO TO 770	E 0831
90050	CALL RTMODE	E 0832
90001	CONTINUE	E 0833
	CALL RECORD	E 0834
	IF (NOEL.GE.NOPTS) GO TO 560	E 0835
90005	CONTINUE	E 0836
	CALL IGRATE1	E 0837
	INT=1	E 0838
	CALL RECYCLE	E 0839
560	IF (FSS(3)) GO TO 770	E 0840
	CALL HALT	E 0841
	IF (FSS(10)) GO TO 690	E 0842
	IF (.NOT.LOGIC(11)) GO TO 570	E 0843
	IEVEN=IEVEN+1	E 0844
	IF (MOD(IEVEN,2).EQ.0) GO TO 690	E 0845

570	CONTINUE	E 0846
	PASS=PASS+1.	E 0847
	DO 580 J=1,IP	E 0848
	DO 580 I=J,IP	E 0849
580	PXTPX(I,J)=PXTPX(J,I)	E 0850
C	PXTPX= (PXTPX)INV	E 0851
	CALL MASCNT (INVSEN,PXTPX,DET1,AA1)	E 0852
	IF (DET1.NE.0.) GO TO 590	E 0853
	WL(18)=.T.	E 0854
	GO TO 750	E 0855
590	AJP=AJ	E 0856
C	DDELA= (PXTPX)(PXTDX)	E 0857
	CALL MASCNT (IMULTB,PXTPX,PXTDX,DDELA)	E 0858
	DO 600 I=1,IP	E 0859
	II=INTP(I)	E 0860
600	DELA(II)=DDELA(I)*DALMLT	E 0861
C	FSS(5) ON TO WRITE AL AND DELA ON TAPE 50	E 0862
	IF (.NOT.FSS(5)) GO TO 670	E 0863
	WRITE (MF,960) RUN,PASS,DET1,DET2,AJP	E 0864
	WRITE (MF,970) DALG(1),((COM,DALG(1)),I=2,IA)	E 0865
	WRITE (MF,980)	E 0866
	WRITE (MF,990) (XBAR(I),I=1,IA)	E 0867
	WRITE (MF,1000)	E 0868
	DO 610 I=1,IA	E 0869
	WRITE (MF,990) (SD(I,J),J=1,IA)	E 0870
610	CONTINUE	E 0871
	WRITE (MF,1010)	E 0872
	DO 620 I=1,IA	E 0873
	WRITE (MF,990) (WT(I,J),J=1,IA)	E 0874
620	CONTINUE	E 0875
	WRITE (MF,1020) ((PARAM(I),AL(I),DELA(I)),I=1,NPAR)	E 0876
	IERR=0	E 0877
	DO 640 I=1,IP	E 0878
	IF (PXTPX(I,I).GT.1.E-20) GO TO 630	E 0879
	IERR=1	E 0880
	WRITE (MF,1030) RUN,PASS,I,I,PXTPX(I,I)	E 0881
	PXTPX(I,I)=1.E-20	E 0882
630	CONTINUE	E 0883
640	DDELA(I)=SQRT(PXTPX(I,I))	E 0884
	IF (IERR.EQ.1) CALL PRINTER	E 0885
	DO 650 I=1,IP	E 0886
	DO 650 J=1,IP	E 0887
	PXTPX(I,J)=PXTPX(I,J)/(DDELA(I)*DDELA(J))	E 0888
	IF (I.EQ.J) PXTPX(I,I)=DDELA(I)	E 0889
650	CONTINUE	E 0890
	WRITE (MF,1040)	E 0891
	DO 660 K=1,IP,8	E 0892
	KK=K+7	E 0893
	IF (KK.GT.IP) KK=IP	E 0894
	WRITE (MF,1050) (DPARAM(KKK),KKK=K,KK)	E 0895
	DO 660 I=1,IP	E 0896
	WRITE (MF,1060) (DPARAM(I),(PXTPX(I,J),J=K,KK))	E 0897
660	CONTINUE	E 0898
	WRITE (MF,1070)	E 0899
670	CONTINUE	E 0900
	DO 680 I=1,NPAR	E 0901
680	AL(I)=AL(I)+DELA(I)	E 0902
	IF (LOGIC(6)) CZDE=CMDE*CMCON	E 0903

690	CONTINUE	E 0904
	IF (,.NOT.LOGIC(1)) GO TO 730	E 0905
	DO 700 I=1,1A	E 0906
	DO 700 J=1,1A	E 0907
	WT(I,J)=SD(I,J)	E 0908
700	WT(J,I)=SD(I,J)	E 0909
	IF (,.NOT.LOGIC(2)) GO TO 720	E 0910
	DO 710 I=1,1A	E 0911
	DO 710 J=1,1A	E 0912
	IF (I.NE.J) WT(I,J)=0.	E 0913
710	CONTINUE	E 0914
720	CONTINUE	E 0915
C	WT= (WT)INV	E 0916
	CALL MASCNT (INVWT,WT,DET2,AA2)	E 0917
	IF (DET2.NE.0.) GO TO 730	E 0918
	WL(19)=.T.	E 0919
	GO TO 750	E 0920
730	CONTINUE	E 0921
	IF (LOGIC(10)) LOGIC(9)=.T.	E 0922
	GO TO 780	E 0923
740	CALL HALT	E 0924
750	CALL DISPLAY	E 0925
	CALL OPERATE	E 0926
	IF (,.NOT.FSS(15)) GO TO 750	E 0927
	DO 760 I=10,19	E 0928
760	WL(I)=.F.	E 0929
	GO TO 780	E 0930
770	CALL HALT	E 0931
780	CONTINUE	E 0932
	WL(20)=.T.	E 0933
	CALL ENDPLOT	E 0934
	IF (,.NOT.FSS(3)) GO TO 920	E 0935
790	CALL UNLODE	E 0936
	CALL CLRABL	E 0937
	NPASS=1	E 0938
	NFREQ=1	E 0939
	NRITE=0	E 0940
	NTYPE=0	E 0941
	TGAIN=TIME*.5	E 0942
	TOFF=-1.	E 0943
	UOFF=-UCRTBI/UMAX	E 0944
800	IF (,.NOT.FSS(1)) GO TO 810	E 0945
	CALL CRTPLOT (1,3,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,AXI,AXMAX,0.	E 0946
	1,LABAX)	E 0947
	CALL CRTPLOT (2,3,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,AYI,AYMAX,0.	E 0948
	1,LABAY)	E 0949
	CALL CRTPLOT (3,3,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,AZI,AZMAX,0.	E 0950
	1,LABAZ)	E 0951
	GO TO 840	E 0952
810	IF (,.NOT.FSS(7)) GO TO 820	E 0953
	CALL CRTPLOT (1,4,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,P,PMAX,0.,LA	E 0954
	1BP)	E 0955
	CALL CRTPLOT (2,4,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,R,RMAX,0.,LA	E 0956
	1BR)	E 0957
	CALL CRTPLOT (3,4,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,V,VMAX,0.,LA	E 0958
	1BV)	E 0959
	CALL CRTPLOT (4,4,NFREQ,NTYPE,NRITE,T,TGAIN,TOFF,LABT,PHI,PHMAX,0.	E 0960
	1,LABPH)	E 0961
	GO TO 840	E 0962

820	IF (.NOT.FSS(8)) GO TO 830	E 0963
	CALL CRTPLOT (1.3.NFREQ.NTYPE.NWRITE.T.TGAIN.TOFF.LABT.DA.DAMAX.0..	E 0964
	1LABDA)	E 0965
	CALL CRTPLOT (2.3.NFREQ.NTYPE.NWRITE.T.TGAIN.TOFF.LABT.DE.DEMAX.0..	E 0966
	1LABDE)	E 0967
	CALL CRTPLOT (3.3.NFREQ.NTYPE.NWRITE.T.TGAIN.TOFF.LABT.DR.DRMAX.0..	E 0968
	1LABDR)	E 0969
	GO TO 840	E 0970
830	CONTINUE	E 0971
	CALL CRTPLOT (1.4.NFREQ.NTYPE.NWRITE.T.TGAIN.TOFF.LABT.U.UMAX.UOFF.	E 0972
	1LABU)	E 0973
	CALL CRTPLOT (2.4.NFREQ.NTYPE.NWRITE.T.TGAIN.TOFF.LABT.W.WMAX.0..LA	E 0974
	1BW)	E 0975
	CALL CRTPLOT (3.4.NFREQ.NTYPE.NWRITE.T.TGAIN.TOFF.LABT.Q.QMAX.0..LA	E 0976
	1BQ)	E 0977
	CALL CRTPLOT (4.4.NFREQ.NTYPE.NWRITE.T.TGAIN.TOFF.LABT.THE.THMAX.0..	E 0978
	1.LABTH)	E 0979
840	CONTINUE	E 0980
	IF (NPASS.EQ.0) GO TO 900	E 0981
	T=-DELX	E 0982
	IF (LDISI(19)) NOEL=NOPTS	E 0983
	DO 890 I=1.NOEL	E 0984
	T=T+DELX	E 0985
	IF (.NOT.FSS(1)) GO TO 850	E 0986
	AXI=AXM(I)	E 0987
	AYI=AYM(I)	E 0988
	AZI=AZM(I)	E 0989
	GO TO 880	E 0990
850	CONTINUE	E 0991
	IF (.NOT.FSS(7)) GO TO 860	E 0992
	P=PM(I)	E 0993
	R=RM(I)	E 0994
	V=VM(I)	E 0995
	PHI=PHM(I)	E 0996
	GO TO 880	E 0997
860	IF (.NOT.FSS(9)) GO TO 870	E 0998
	DA=FDA(I)	E 0999
	DE=FDE(I)	E 1000
	DR=FDR(I)	E 1001
	GO TO 880	E 1002
870	U=UM(I)	E 1003
	W=WM(I)	E 1004
	Q=QM(I)	E 1005
	THE=THM(I)	E 1006
880	CALL RITECRT (.T...F..MAXPAGE)	E 1007
890	CONTINUE	E 1008
	CALL ENDPLOT	E 1009
	IF (FSS(8)) GO TO 910	E 1010
	CALL CLRTABL	E 1011
	NPASS=0	E 1012
	NFREQ=NOITSPS	E 1013
	NWRITE=1	E 1014
	NTYPE=-1	E 1015
	GO TO 800	E 1016
900	CALL PLAYBAK(910S)	E 1017
	CALL RITECRT (.T...F..MAXPAGE)	E 1018
	GO TO 900	E 1019
910	CALL ENDPLOT	E 1020

920	CALL DSPLAY	E 1021
	CALL OPERATE	E 1022
	IF (FSS(14)) GO TO 790	E 1023
	IF (.NOT.FSS(13)) GO TO 920	E 1024
	CALL CLRPLT	E 1025
	IF (IPRINT.NE.4) CALL ERASE	E 1026
	WL(20)=.F.	E 1027
	GO TO 10	E 1028
90004	CONTINUE	E 1029
	CALL CALPLT (0.,0.,999)	E 1030
	CALL ATERM	E 1031
90014	CONTINUE	E 1032
90015	CONTINUE	E 1033
	RETURN	E 1034
960	FORMAT (/6H RUN=.F4.0.7H PASS=.F4.0.7H DET1=.E14.6.7H DET2=.E1	E 1035
	14.6.6H AJP=.E14.6)	E 1036
970	FORMAT (/39H ACTIVE ALGORITHM VARIABLES ARE . . . .A3.10(A1.A3))	E 1037
980	FORMAT (/19H PACKED MEAN ARRAY)	E 1038
990	FORMAT (11E12.4)	E 1039
1000	FORMAT (/32H PACKED NOISE COVARIANCE MATRIX)	E 1040
1010	FORMAT (/22H PACKED WEIGHT MATRIX)	E 1041
1020	FORMAT (/2X.3(5HPARAM.6X.5HVALUE.10X.6HCHANGE.5X)/(3(2XA5.2XE13.6.	E 1042
	12XE13.6)))	E 1043
1030	FORMAT (/6H RUN=.F6.0.7H PASS=.F6.0.8H PXTPX(.12.1H.,.12.2H)=.E1	E 1044
	14.6)	E 1045
1040	FORMAT (/38H MODIFIED PARAMETER COVARIANCE MATRIX)	E 1046
1050	FORMAT (/8(10XA5))	E 1047
1060	FORMAT (2XA5.8(E15.6))	E 1048
1070	FORMAT (1H1)	E 1049
	END	E 1050

## PROGRAM USAGE

The use of the program is demonstrated by showing the setup of the longitudinal equations of motion, run procedure, and output listings for the test case. The test case consists of pseudo flight data, which are generated by integrating the longitudinal equations of motion for fixed parameter values (called the true values) and then adding random number sequences (measurement noise) to the variables. The parameter values are then offset to become the starting point of the estimation program. The integration scheme (from subroutine IGRATE1) used is second-order Adams-Bashforth, a 1-pass integration scheme. (See ref. 1.)

### Test Case Setup

The longitudinal equations of motion are

$$\dot{u} = -qw - g \sin \theta + \frac{1}{2} \frac{\rho}{m} V^2 S (C_{X,o}) \quad (10)$$

$$\dot{w} = qu + g \cos \theta + \frac{1}{2} \frac{\rho}{m} V^2 S (C_{Z,o} + C_{Z\alpha_a} \alpha_a + C_{Z\delta_e} \delta_e) \quad (11)$$

$$\dot{q} = \frac{1}{2} \frac{\rho}{I_Y} V^2 S \bar{c} \left( C_{m,o} + C_{m,\alpha_a} \alpha_a + C_{m,q} \frac{q \bar{c}}{2V} + C_{m,\delta_e} \delta_e \right) \quad (12)$$

$$\dot{\theta} = q \quad (13)$$

where

$$\delta_e = \begin{cases} 0.1 \sin 2.5t & (0 \leq t \leq \pi/1.25) \\ 0 & (t > \pi/1.25) \end{cases}$$

$$V = \sqrt{u^2 + w^2}$$

$$\alpha_a = \tan^{-1} \frac{w}{u}$$

The longitudinal equations are generated from the equations of motion in appendix B by the variable-dimensioning arrays described in appendix D.

For the active equation variables  $u$ ,  $w$ ,  $q$ , and  $\theta$ , the input array INTX is

$$\text{INTX} = (1, 0, 1, 0, 1, 0, 1, 0)$$

and hence

$$\text{INTV} = (1, 3, 5, 7, 0, \dots, 0) \quad (\text{IV} = 4)$$

For the active performance index variables  $u$ ,  $w$ ,  $q$ , and  $\theta$ , the input array INTY is

$$\text{INTY} = (1, 0, 1, 0, 1, 0, 1, 0, 0, 0, 0)$$

and hence

$$\text{INTA} = (1, 3, 5, 7, 0, \dots, 0) \quad (\text{IA} = \text{IA1} = 4)$$

For the active parameters (see TABLE array in section "Display Arrays"), all the  $INTEG_{40}(I)$  values are 0 except for  $I = 2, 8, 9, 11, 13, 14, 16, 17$ , and hence

$$INTP = (2, 8, 9, 11, 13, 14, 16, 17, 0, \dots, 0) \quad (IP = 8)$$

By putting in these arrays and the FORTRAN variables listed in the subroutine DSPLAY arrays, the test case is set up.

### Test Case Run Procedure

The program deck or the data cell control cards are read into the computer after selecting RESET mode and both RELEASE switches, and FSS 3, 4, 9, and 16 true. The dynamic check case is then run before the test case or normal use of the parameter estimation program.

The step-by-step procedure for running the test case from the control console is described as follows:

<u>Steps</u>	<u>Task</u>
(1) Change constants, $\bar{\alpha}$ and activeness by means of DDDU. Depress FSS(3), FSS(4), FSS(5), and FSS(9), and then release FSS(4).	Program initialization.
(2) Depress PRINT switch.	I.C. printout of true parameters.
(3) When RESET light comes on, depress lower RELEASE switch.	Return to level (4,0).
(4) Depress OPER switch.	OPERATE to fill flight-data arrays with pseudo data.
(5) When WL(20) comes on: release FSS(3) and FSS(9); depress RESET switch and depress FSS(13), then release FSS(13).	End of pseudo data fill and return to RESET mode.
(6) Change to desired standard deviations and change IPRINT to 3 by means of the the DDDU, then depress PRINT switch.	Adds random numbers to pseudo data and prints characteristics.
(7) When RESET light comes on, depress lower RELEASE switch.	Return to level (4,0).

<u>Steps</u>	<u>Task</u>
(8) Change $\tilde{\alpha}$ to offset values and change IPRINT to 1, then depress PRINT switch.	Inputs $\tilde{\alpha}$ offsets and gets I.C. printout.
(9) When RESET light comes on, depress lower RELEASE switch.	Return to level (4,0).
(10) Depress FSS(10) and OPER switch.	OPERATE to obtain initial weighting.
(11) When WL(20) comes on, release FSS(10) and depress FSS(13).	OPERATE automatically updating $\tilde{\alpha}$ .
(12) Release FSS(13) at convergence.	Stops run.
(13) When WL(20) comes on: depress RESET switch; and depress FSS(13), then release.	Return to RESET mode.
(14) Depress PRINT switch.	Routes maximum likelihood printout.
(15) When RESET light comes on, depress lower RELEASE switch.	Return to level (4,0).

### Output Listings

Four output listings are presented to illustrate the computer printouts. (Note that variables in  $\tilde{y}_j$  are referred to as algorithm variables in the output listings.)

- (1) Random number characteristics where RN and RSD denote the means and standard deviations, respectively, used in the program
- (2) Initial condition printout
  - (a) Showing the true parameter values used to generate the pseudo test case
  - (b) Showing the offset parameter values used as the starting point for the estimation procedure

- (3) Maximum likelihood printout for each iteration (a total of 11) where the modified covariance matrix for the parameters is

$$\begin{bmatrix} \sigma_{\alpha_{i1}} & \rho_{\alpha_{i1}\alpha_{i2}} & \dots & \rho_{\alpha_{i1}\alpha_{iIP}} \\ \rho_{\alpha_{i2}\alpha_{i1}} & \sigma_{\alpha_{i2}} & \dots & \rho_{\alpha_{i2}\alpha_{iIP}} \\ . & . & \dots & . \\ . & . & \dots & . \\ . & . & \dots & . \\ \rho_{\alpha_{iIP}\alpha_{i1}} & \rho_{\alpha_{iIP}\alpha_{i2}} & \dots & \sigma_{\alpha_{iIP}} \end{bmatrix}$$

Tabulated results of the test cases are presented in reference 1. Figure 2 shows the CalComp plot representation of the CRT display of the converged solution and the pseudo data, and the control inputs.

#### RANDOM NUMBER CHARACTERISTICS

RUN= 1 NOPTS= 201

DRM(I)	RN(I)	DRSD(I)	RSD(I)
0.	-7.944999E-15	5.000000E-01	5.000000E-01
0.	3.641090E-15	3.000000E+00	3.000000E+00
0.	-3.866448E-17	2.000000E-02	2.000000E-02
0.	-5.153423E-16	2.000000E-02	2.000000E-02

## INITIAL CONDITION PRINTOUT (TRUE PARAMETER VALUES)

```

RUN= 1
LOGIC( 1)=T LOGIC( 2)=T LOGIC( 3)=F LOGIC( 4)=F LOGIC( 5)=F LOGIC( 6)=F
LOGIC( 7)=F LOGIC( 8)=F LOGIC( 9)=F LOGIC(10)=F LOGIC(11)=F

ACTIVE EQUATION VARIABLES ARE . . . U ,W ,Q ,THE
ACTIVE ALGORITHM VARIABLES ARE . . . U ,W ,Q ,THE

PARAM  VALUE  ACT  PARAM  VALUE  ACT  PARAM  VALUE  ACT  PARAM  VALUE  ACT  PARAM  VALUE  ACT
UQ      2.999000E+02  F  CXO      1.120000E-01  T  CXAL      0.      F  CXQ      0.      F  THEO      8.000000E-02  F
PHIO      0.      F  WO      5.000000E+00  F  CZO      -1.290000E+00  T  CZAL      -4.590000E+00  T  CZQ      0.      F
CZDE     -4.930000E+00  T  QO      0.      F  CMO      1.990000E-02  F  CMAL      -8.360000E-01  T  CMALD      0.      F
CMO      -3.200000E+01  T  CMDE     -3.100000E+00  F  VQ      0.      F  CYO      0.      F  CYB      0.      F
CY8D      0.      F  CYP      0.      F  CYR      0.      F  CYDR      0.      F  PD      0.      F
CLO      0.      F  CLB      0.      F  CLB      0.      F  CLP      0.      F  CLR      0.      F
CLDR      0.      F  CLDA      0.      F  RO      0.      F  CNO      0.      F  CNB      0.      F
CNRD      0.      F  CNP      0.      F  CNR      0.      F  CNDR      0.      F  CNDA      0.      F

UMULT = 1.000000E+00  VMULT = 1.000000E+00  WMULT = 1.000000E+00  PMULT = 1.000000E+00  QMULT = 1.000000E+00  RMULT = 1.000000E+00
THMULT = 1.000000E+00  PHMULT = 1.000000E+00  AXMULT = 1.000000E+00  AYMULT = 1.000000E+00  AZMULT = 1.000000E+00  DAMULT = 1.000000E+00
DEMULT = 1.000000E+00  DRMULT = 1.000000E+00  UBIA = 0.      VBIAS = 0.      PBIA = 0.      WBIAS = 0.      AXBIAS = 0.      AYBIAS = 0.
QBIA = 0.      RBIAS = 0.      DBIAS = 0.      THBIAS = 0.      DRBIAS = 0.      PBBIAS = 0.      ABBIAS = 0.      AVBIAS = 0.
AZBIAS = 0.      DABIAS = 0.      DEBIAS = 0.

AIX      = 1.500000E+05  AIY      = 1.280000E+05  AIZ      = 2.700000E+05  AIXZ      = 0.      AIXZ      = 0.      WEIGHT = 3.605000E+04  GRAV      = 3.217000E+01
RHO      = 2.185000E-03  S        = 5.344000E+02  B        = 6.750000E+01  CBAR      = 8.070000E+00  TS        = 0.      DEAMPL = 1.000000E-01  DEFREQ = 2.500000E+00
ALPHAT = 0.      DT        = 2.500000E-02  TT        = 5.000000E-02  XY        = 0.      YY        = 0.      ZY        = 0.

XX      = 0.      YX      = 0.      ZX      = 0.      XY      = 0.      YY      = 0.      ZY      = 0.
XZ      = 0.      YZ      = 0.      ZZ      = 0.      ZZ      = 0.

CMCON = 0.      DALMLT = 1.000000E+00  UCRTBI = 2.100000E+02  AIW      = 0.      CTO      = 0.      CTTO      = 0.
CTB      = 0.      CTBT      = 0.      D        = 0.      CAPDT = 0.      ELBAR = 0.      ELTP      = 0.
RB        = 0.      PPER      = 0.      TPER      = 0.      BTBIAS = 0.      PPERBI = 0.      TPERBI = 0.

TX      = 0.      TY      = 0.      TZ      = 0.      AMX      = 0.      AMY      = 0.      AMZ      = 0.

NOPTS= 201  INC= 1

```

# INITIAL CONDITION PRINTOUT (OFFSET PARAMETER VALUES)

RUN= 1

LOGIC( 1)=T LOGIC( 2)=T LOGIC( 3)=F LOGIC( 4)=F LOGIC( 5)=F LOGIC( 6)=F  
LOGIC( 7)=F LOGIC( 8)=F LOGIC( 9)=F LOGIC(10)=F LOGIC(11)=F

ACTIVE EQUATION VARIABLES ARE . . . U . W . Q . THE

ACTIVE ALGORITHM VARIABLES ARE . . . U . W . Q . THE

PARAM	VALUE	ACT	PARAM	VALUE	ACT	PARAM	VALUE	ACT	PARAM	VALUE	ACT	PARAM	VALUE	ACT	PARAM	VALUE	ACT
UD	2.099000E+02	F	CXO	1.000000E-01	T	CXAL	0.	F	CXQ	0.	F	THEO	8.000000E-02	F			
PHIO	0.	F	WO	5.000000E+00	F	CZO	-8.000000E-01	T	CZAL	-3.500000E+00	T	CZQ	0.	F			
CZDE	-4.000000E+00	T	OO	0.	F	CMO	1.000000E-02	T	CMAL	-5.000000E-01	T	CMALD	0.	F			
CMQ	-2.500000E+01	T	CHDE	-2.000000E+00	F	VO	0.	F	CYO	0.	F	PO	0.	F			
CYBD	0.	F	CYP	0.	F	CYR	0.	F	CYDR	0.	F	PO	0.	F			
CLO	0.	F	CLB	0.	F	CLBD	0.	F	CLP	0.	F	CLR	0.	F			
CLDR	0.	F	CLDA	0.	F	RO	0.	F	CNO	0.	F	CNB	0.	F			
CNBD	0.	F	CNP	0.	F	CNR	0.	F	CNDR	0.	F	CNDA	0.	F			
UMULT	1.000000E+00		VMULT	1.000000E+00		WMULT	1.000000E+00		PMULT	1.000000E+00		QMULT	1.000000E+00				
THMULT	1.000000E+00		PHMULT	1.000000E+00		AKMULT	1.000000E+00		AYMULT	1.000000E+00		AZMULT	1.000000E+00				
DEMULT	1.000000E+00		DRMULT	1.000000E+00		UBIAS	0.		VBIAS	0.		WBIAS	0.				
QBIAAS	0.		RBIAAS	0.		THBIAAS	0.		PHBIAAS	0.		AXBIAAS	0.				
AZBIAAS	0.		DBIAAS	0.		DEBIAAS	0.		DRBIAAS	0.							
AIX	1.500000E+05		AIY	1.280000E+05		AIZ	2.700000E+05		AIXZ	0.							
RHO	2.186000E-03		S	5.344000E+02		B	6.750000E+01		CBAR	8.070000E+00							
ALPHAT	0.		DT	2.500000E-02		TT	5.000000E-02		TS	0.							
XX	0.		YX	0.		ZX	0.		XY	0.		YY	0.				
XZ	0.		YZ	0.		ZZ	0.										
CMCON	0.		DALMLT	1.000000E+00		UCRTBI	2.100000E+02		AIW	0.		CTO	0.				
CTB	0.		CTBT	0.		D	0.		CAPDT	0.		ELBAR	0.				
RB	0.		PPER	0.		TPER	0.		BTBIAS	0.		PPERBI	0.				
TX	0.		TY	0.		TZ	0.		AMX	0.		AMY	0.				
NOPTS= 201			INC= 1														

## ALGORITHM PRINTOUT

RUN= 1 PASS= 0 DET1= 2.184853E+17 DET2= 2.911344E+00 AJP= 1.322543E+05

ACTIVE ALGORITHM VARIABLES ARE . . . U .W .Q .THE

PACKED MEAN ARRAY

-1.7961E+01 -5.1772E+00 2.6770E-02 1.4646E-01

PACKED NOISE COVARIANCE MATRIX

5.9592E+02 4.9857E+01 -3.3688E-01 -4.0594E+00  
 4.9857E+01 6.2029E+01 -1.1152E-01 -4.6932E-01  
 -3.3688E-01 -1.1152E-01 2.5438E-03 3.5111E-03  
 -4.0594E+00 -4.5932E-01 3.5111E-03 3.0962E-02

PACKED WEIGHT MATRIX

1.6781E-03 0. 0. 0.  
 0. 1.6122E-02 0. 0.  
 0. 0. 3.9311E+02 0.  
 0. 0. 0. 3.2298E+01

PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE
UO	2.099000E+02	0.	CXO	1.030000E-01	5.441510E-03	CXAL	0.	0.			
CXO	0.	0.	THEO	8.000000E-02	0.	PHIO	0.	0.			
WO	5.000000E+00	0.	CZO	-8.300000E-01	-4.528541E-01	CZAL	-3.500000E+00	-7.836530E-01			
CZO	0.	0.	CZDE	-4.000000E+00	-1.110759E+00	QO	0.	0.			
CMO	1.000000E-02	5.925843E-03	CMAL	-5.300000E-01	-2.605739E-01	CMALD	0.	0.			
CMQ	-2.500000E+01	-1.671633E+01	CMDE	-2.000000E+00	-1.079041E+00	VO	0.	0.			
CYO	0.	0.	CYB	0.	0.	CYBD	0.	0.			
CYP	0.	0.	CYR	0.	0.	CYDR	0.	0.			
PO	0.	0.	CLO	0.	0.	CLB	0.	0.			
CLBD	0.	0.	CLP	0.	0.	CLR	0.	0.			
CLDR	0.	0.	CLOA	0.	0.	RO	0.	0.			
CNO	0.	0.	CNB	0.	0.	CNB0	0.	0.			
CNP	0.	0.	CNR	0.	0.	CNDR	0.	0.			
CNDA	0.	0.									

MODIFIED PARAMETER COVARIANCE MATRIX

PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE
CXO	1.329714E-02	-5.095304E-02	CZAL	-9.669675E-03	-1.822915E-01	CMO	1.331663E-01	2.021305E-01	CMQ	9.175058E-02	9.175058E-02
CZO	-5.095304E-02	4.170712E-02	-8.604703E-01	-2.979134E-01	3.488151E-02	-6.953266E-02	3.127489E-01	-5.514987E-01	3.704323E+00	6.106548E-01	
CZAL	-9.669675E-03	-8.604703E-01	6.883962E-01	4.127499E-01	-6.953266E-02	1.037372E-01	-5.025312E-01	5.460868E-01	1.521775E-01	1.266476E-01	
CZDE	-1.822915E-01	-2.979134E-01	4.127499E-01	1.351781E+00	1.037372E-01	2.943932E-03	-6.064017E-01	1.265490E-02	1.521775E-01	1.266476E-01	
CMO	1.331663E-01	3.488151E-02	-6.953266E-02	-5.025312E-01	-6.064017E-01	5.460868E-01	1.265490E-02	3.704323E+00	6.106548E-01	1.266476E-01	
CMAL	2.031905E-01	3.127489E-01	-3.314547E-01	-4.601351E-01	-4.601351E-01	3.379593E-01	1.521775E-01	1.266476E-01	1.266476E-01	1.266476E-01	
CMQ	9.175058E-02	4.412546E-01	-5.514987E-01	-4.601351E-01	-4.601351E-01	3.379593E-01	1.521775E-01	1.266476E-01	1.266476E-01	1.266476E-01	
CMDE	1.719726E-01	-8.200848E-02	2.319488E-02	-4.060792E-01	-4.060792E-01	3.379593E-01	1.521775E-01	1.266476E-01	1.266476E-01	1.266476E-01	

# ALGORITHM PRINTOUT - Continued

RUN= 1 PASS= 1 DET1= 4.566813E+15 DET2= 2.911344E+00 AJP= 3.417685E+03

ACTIVE ALGORITHM VARIABLES ARE . . . U . W . Q . THE

PACKED MEAN ARRAY

-1.9312E+00 -2.7791E-02 2.6002E-03 1.5732E-02

PACKED NOISE COVARIANCE MATRIX

6.6354E+00 -3.8881E-01 1.8591E-04 -4.4760E-02  
-3.8881E-01 1.0367E+01 3.3539E-03 1.0495E-02  
1.8591E-04 3.3539E-03 5.6745E-04 3.5200E-05  
-4.4760E-02 1.0495E-02 3.5200E-05 7.9216E-04

PACKED WEIGHT MATRIX

1.6781E-03 0. 0.  
0. 1.6122E-02 0.  
0. 0. 3.9311E+02 0.  
0. 0. 0. 3.2298E+C1

PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE
UD	2.099000E+02	0.	CXO	1.054415E-01	1.527980E-03	CXAL	0.	0.	CXAL	0.	0.
CXQ	0.	0.	THEO	8.000000E-02	0.	PHIO	0.	0.	PHIO	0.	0.
WO	5.000000E+00	0.	CZO	-1.252854E+00	-3.605968E-02	CZAL	-4.	-2.83653E+00	CZAL	-4.	-2.83653E+00
CZO	0.	0.	CZDE	-5.110759E+00	5.156919E-01	QO	0.	0.	QO	0.	0.
CMO	1.592594E-02	3.606238E-03	CMAL	-7.605739E-01	-4.926042E-02	CMALD	0.	0.	CMALD	0.	0.
CMQ	-4.171633E+01	9.767419E+00	CMDE	-3.079041E+00	-2.713502E-02	VO	0.	0.	VO	0.	0.
CYO	0.	0.	CYB	0.	0.	CYBD	0.	0.	CYBD	0.	0.
CYP	0.	0.	CYR	0.	0.	CYDR	0.	0.	CYDR	0.	0.
PO	0.	0.	CLO	0.	0.	CL8	0.	0.	CL8	0.	0.
CL8D	0.	0.	CLP	0.	0.	CLR	0.	0.	CLR	0.	0.
CLDR	0.	0.	CLOA	0.	0.	RO	0.	0.	RO	0.	0.
CND	0.	0.	CNB	0.	0.	CN8D	0.	0.	CN8D	0.	0.
CNP	0.	0.	CNR	0.	0.	CNDR	0.	0.	CNDR	0.	0.
CNDA	0.	0.									

MODIFIED PARAMETER COVARIANCE MATRIX

PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE
CXO	1.388403E-02	2.483655E-02	CZAL	6.178364E-02	-1.546951E-01	CMO	3.617779E-01	3.617779E-01	CMQ	1.099767E-01	1.099767E-01
CZO	2.483655E-02	3.007918E-02	CZDE	-1.132862E-01	1.132862E-01	CMO	5.954329E-02	5.954329E-02	CMQ	1.840243E-01	1.840243E-01
CZAL	6.178364E-02	-6.082048E-01	CZDE	3.301225E-01	3.301225E-01	CMO	6.339838E-02	6.339838E-02	CMQ	-4.118849E-01	-4.118849E-01
CZDE	-1.546951E-01	-1.132862E-01	CZDE	1.431255E+00	1.431255E+00	CMO	3.045813E-01	3.045813E-01	CMQ	-3.105557E-01	-3.105557E-01
CMO	3.617779E-01	5.954329E-02	CMO	3.045813E-01	3.045813E-01	CMO	2.897161E-03	2.897161E-03	CMQ	-2.170690E-01	-2.170690E-01
CMQ	1.099767E-01	1.840243E-01	CMQ	-2.416043E-01	-4.783760E-01	CMQ	-5.553772E-01	-5.553772E-01	CMQ	-1.756323E-01	-1.756323E-01
CMQ	1.840243E-01	1.840243E-01	CMQ	-4.118849E-01	-3.105557E-01	CMQ	2.170690E-01	2.170690E-01	CMQ	4.967757E+00	4.967757E+00
CMQ	1.802458E-01	-9.669551E-02	CMQ	1.112003E-02	-3.501976E-01	CMQ	1.604847E-01	1.604847E-01	CMQ	7.737113E-01	7.737113E-01
CMQ			CMQ			CMQ			CMQ		

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1  PASS= 2  DET1= 4.174016E+24  DET2= 3.092048E-05  AJP= 1.902637E+03
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ACTIVE ALGORITHM VARIABLES ARE . . . U , W , Q , THE

### PACKED MEAN ARRAY

3.7179E-01 -1.3210E-01 3.4749E-04 1.4569E-03

PACKED NOISE COVARIANCE MATRIX

4.8250E-01 2.1328E-02 -3.8777E-04 -7.9297E-04

2.1328E-02 8.9826E+00 -2.3407E-03 -1.4428E-03

3.8777E-04 -2.3407E-03 3.9899E-04 6.5345E-06

7.9297E-04 -1.4428E-03 6.5345E-06 4.0680E-04

## PACKED WEIGHT MATRIX

1.5071E-01 0. 0.

0. 9.6463E-02 0. 0.

0.0. 0.0. 1.7623E+03 0

0.	0.	0.	1.2624E+03
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PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE
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NAME	VALUE	UNIT	VALUE	UNIT
UO	2.099000E+02	0.	1.069695E-01	0.
UO	2.099000E+02	0.	2.453560E-03	0.

	CX0	THEO	PHIO	O.
8.000000E-02	0.	0.	0.	0.

Variable	Value	Unit
CZ0	-1.288914E+00	CZAL
CZ1	-2.531949E-03	CZAL
CZ2	-4.546204E+00	CZAL
CZ3	1.177127E-01	CZAL

0.	0.	0.	0.
CZ0	CZ0E	-4.595667E+00	-5.297208E-02
0.	0.	0.	0.

CMD	1.953208E-02	-1.193395E-04	CMAL	-8.098343E-01	-9.923283E-03	CMALD	0.
CMD							0.

CMQ	-3.194891E+01	-1.180978E+00	CMDE	-3.106176E+00	1.608278E-02	VD	0.
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	CY0	CY8	CY8D	CY0
0.	0.	0.	0.	0.

	CYP	CYR	CYDR	CYD
0.	0.	0.	0.	0.

	PO	O <sub>2</sub>	CLO	O <sub>2</sub>	CLB	O <sub>2</sub>
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.2	0.2	0.2	0.2	0.2	0.2	0.2
0.3	0.3	0.3	0.3	0.3	0.3	0.3
0.4	0.4	0.4	0.4	0.4	0.4	0.4
0.5	0.5	0.5	0.5	0.5	0.5	0.5
0.6	0.6	0.6	0.6	0.6	0.6	0.6
0.7	0.7	0.7	0.7	0.7	0.7	0.7
0.8	0.8	0.8	0.8	0.8	0.8	0.8
0.9	0.9	0.9	0.9	0.9	0.9	0.9
1.0	1.0	1.0	1.0	1.0	1.0	1.0

	CLBD	CLP	CLR
0.0	0.0	0.0	0.0
0.1	0.1	0.1	0.1
0.2	0.2	0.2	0.2
0.3	0.3	0.3	0.3
0.4	0.4	0.4	0.4
0.5	0.5	0.5	0.5
0.6	0.6	0.6	0.6
0.7	0.7	0.7	0.7
0.8	0.8	0.8	0.8
0.9	0.9	0.9	0.9
1.0	1.0	1.0	1.0

	CLDR	0.	0.	0.	RO	0.	0.
	CLDA	0.	0.	0.	CUG	0.	0.

CND	0.0	0.0
CNB	0.0	0.0
CNB0	0.0	0.0
CN80	0.0	0.0
CN90	0.0	0.0

	CNR	CNR	CNR
0.0	0.0	0.0	0.0
0.1	0.1	0.1	0.1
0.2	0.2	0.2	0.2
0.3	0.3	0.3	0.3
0.4	0.4	0.4	0.4
0.5	0.5	0.5	0.5
0.6	0.6	0.6	0.6
0.7	0.7	0.7	0.7
0.8	0.8	0.8	0.8
0.9	0.9	0.9	0.9
1.0	1.0	1.0	1.0

CNDA 0. 0.

### UNOBTAINED PARAMETER COVARIANCE MATRICES

# MODIFIED PARAMETER COVARIANCE MATRIX

CXO	CZO	CZAL	CZDE	CMO	CMAL	CMQ	CMDE
CXO	9.4977733E-02	-2.136102E-01	-5.138401E-01	1.874854E-01	1.017347E-01	3.995688E-01	3.349302E-01
CXO	2.560663E-03	-7.001607E-01	-1.081150E-01	5.642271E-01	1.353722E-02	3.471616E-01	2.489999E-03
CZO	9.4977733E-02	-2.136102E-01	-5.138401E-01	1.874854E-01	1.017347E-01	3.995688E-01	3.349302E-01
CZAL	9.4977733E-02	-2.136102E-01	-5.138401E-01	1.874854E-01	1.017347E-01	3.995688E-01	3.349302E-01
CZDE	9.4977733E-02	-2.136102E-01	-5.138401E-01	1.874854E-01	1.017347E-01	3.995688E-01	3.349302E-01
CMO	9.4977733E-02	-2.136102E-01	-5.138401E-01	1.874854E-01	1.017347E-01	3.995688E-01	3.349302E-01
CMAL	9.4977733E-02	-2.136102E-01	-5.138401E-01	1.874854E-01	1.017347E-01	3.995688E-01	3.349302E-01
CMQ	9.4977733E-02	-2.136102E-01	-5.138401E-01	1.874854E-01	1.017347E-01	3.995688E-01	3.349302E-01
CMDE	9.4977733E-02	-2.136102E-01	-5.138401E-01	1.874854E-01	1.017347E-01	3.995688E-01	3.349302E-01

## ALGORITHM PRINTOUT – Continued

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RUN= 1 PASS= 3 DET1= 2.173460E+27 DET2= 7.034618E-07 AJP= 1.830437E+03

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ACTIVE ALGORITHM VARIABLES ARE . . . U , W , Q , THE

### PACKED MEAN ARRAY

..-1.3953E-02 -1.8858E-02 2.1345E-04 9.9433E-04

PACKED NOISE COVARIANCE MATRIX

2.5447E-01 4.8338E-02 -4.5240E-04 -1.0977E-03  
4.8338E-02 8.3851E+00 -2.5297E-03 -1.5680E-03  
-4.5240E-04 -2.6297E-03 3.9852E-04 6.0384E-05  
-1.0977E-03 -1.5680E-03 6.0384E-06 3.9940E-04

PACKED WEIGHT MATRIX

2.0726E+00	0.	0.	0.
C.	1.1133E-01	0.	0.
C.	0.	2.5063E+03	0.
0.	0.	0.	2.4582E+03

PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE
UU	2.099000E+02	0.	CXQ	1.094231E-01	6.475541E-04	CXAL	0.	0.
CXCXQ	0.	0.	THQ	8.030000E-02	0.	PHQ	0.	0.
WQ	5.000000E+00	0.	CZQ	-1.291446E+00	1.668846E-03	CZAL	-4.428492E+00	-6.331718E-03
CZQ	0.	0.	CZQE	-4.648639E+00	-2.386607E-01	QO	0.	0.
CMQ	1.941274E-02	1.507396E-04	CMAL	-8.197576E-01	-2.129250E-03	CMALD	0.	0.
CMQ	-3.312989E+01	4.566294E-01	CMDE	-3.090094E+00	1.586320E-02	VO	0.	0.
CYQ	0.	0.	CYB	0.	0.	CYBD	0.	0.
CYP	0.	0.	CYR	0.	0.	CYDR	0.	0.
CPQ	0.	0.	CLQ	0.	0.	CLB	0.	0.
CLBD	0.	0.	CLP	0.	0.	CLR	0.	0.
CLQR	0.	0.	CLQA	0.	0.	RO	0.	0.
CNQ	0.	0.	CNB	0.	0.	CNBD	0.	0.
CNP	0.	0.	CNR	0.	0.	CNDR	0.	0.

MODIFIED PARAMETER COVARIANCE MATRIX

	CXO	CZO	CZAL	CZDE	CMO	CMAL	CMQ	CMDE
CXO	1.799161E-03	1.027426E-01	-1.115902E-01	-6.873052E-01	1.212894E-01	1.961719E-01	4.961370E-01	3.312523E-01
CXO	1.027426E-01	7.962693E-03	-6.98143E-01	-3.52591E-02	6.651202E-01	1.217704E-03	3.09370E-01	-3.752007E-02
CZAL	-3.115902E-01	-6.98143E-01	2.272022E-01	3.666614E-01	-1.465825E-01	3.353992E-02	-6.2033004E-01	-1.540218E-01
CZDE	-6.873052E-01	-3.52591E-02	3.666614E-01	4.306289E-01	3.803290E-01	-6.177207E-01	-2.67259E-01	-2.092242E-01
CMO	1.212894E-01	6.651202E-01	-1.465825E-01	3.803290E-01	8.518354E-04	4.379967E-01	1.013430E-01	-3.029219E-02
CMAL	1.961719E-01	2.177C46E-03	3.353992E-02	-6.177207E-01	-4.379967E-01	1.7523357E-02	-2.023736E-01	-4.861965E-02
CMQ	4.961370E-01	3.09370E-01	-6.2033004E-01	-2.367259E-01	1.013430E-01	1.217704E-03	1.294449E+00	7.439008E-01
CMDE	3.312523E-01	-3.752007E-02	-1.540218E-01	-2.092242E-01	3.029219E-02	-4.861965E-02	7.439008E-01	5.804489E-02

## ALGORITHM PRINTOUT - Continued

RUN= 1 PASS= 4 DET1= 1.140506E+28 DET2= 3.585114E-07 AJP= 1.838583E+03

ACTIVE ALGORITHM VARIABLES ARE . . . U , W , Q , THE

## PACKED MEAN ARRAY

-9.0181E-03 -5.4658E-02 2.9479E-04 1.1456E-03

## PACKED NOISE COVARIANCE MATRIX

2.4623E-01 4.2017E-02 -4.2549E-04 -1.0382E-03  
 4.2017E-02 8.9002E+00 -2.8076E-03 -1.3149E-03  
 -4.2549E-04 -2.8076E-03 3.9913E-04 5.0420E-06  
 -1.0382E-03 -1.3149E-03 5.0420E-06 3.9828E-04

## PACKED WEIGHT MATRIX

3.9298E+00 0. 0. 0.  
 0. 1.1258E-01 0. 0.  
 0. 0. 2.5093E+C3 0.  
 0. 0. 0. 2.5037E+03

PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE
U0	2.099000E+02	0.	CX0	1.100710E-01	1.404210E-05	CXAL	0.	0.
CX0	0.	0.	THEO	8.000000E-02	0.	PH10	0.	0.
W0	5.000000E+00	0.	CZ0	-1.289777E+00	5.805288E-04	CZAL	-4.434823E+00	-7.395059E-04
CZ0	0.	0.	CZDE	-4.886699E+00	-3.865240E-02	Q0	0.	0.
CM0	1.956348E-02	3.363499E-05	CMAL	-8.218868E-01	2.290303E-04	CMALD	0.	0.
CW0	-3.267326E+C1	-1.190056E-01	CMDE	-3.074230E+00	-1.139747E-02	V0	0.	0.
CY0	0.	0.	CY8	0.	0.	CY8D	0.	0.
CYP	0.	0.	CYR	0.	0.	CYDR	0.	0.
PO	0.	0.	CLO	0.	0.	CLB	0.	0.
CLRD	0.	0.	CLP	0.	0.	CLR	0.	0.
CLDR	0.	0.	CLDA	0.	0.	RO	0.	0.
CND	0.	0.	CNB	0.	0.	CNBD	0.	0.
CNP	0.	0.	CNR	0.	0.	CNDR	0.	0.
CNDA	0.	0.						

## MODIFIED PARAMETER COVARIANCE MATRIX

PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE
CX0	1.739725E-03	9.388827E-02	CZAL	-3.183256E-01	-7.336532E-01	CM0	8.210136E-02	2.555880E-01
CZ0	9.388827E-02	7.811771E-03	CZDE	-7.045692E-01	-2.638751E-02	CMQ	4.436670E-01	4.436670E-01
CZAL	-3.183256E-01	-7.045692E-01	CMAL	2.235314E-01	3.650897E-01	CMQ	3.089331E-01	-5.232541E-02
CZDE	-7.045692E-01	-2.638751E-02	CMDE	-1.507491E-01	3.787850E-01	CMQ	-6.420382E-01	-1.491636E-01
CM0	8.210136E-02	6.745658E-01	CMQ	-1.507491E-01	3.787850E-01	CMQ	-2.405253E-01	-2.006387E-01
CMAL	2.555880E-01	1.992884E-02	CMQ	2.977621E-02	-6.449009E-01	CMQ	7.523306E-02	-4.788829E-02
CMQ	4.436670E-01	3.089331E-01	CMQ	-6.449009E-01	-2.405253E-01	CMQ	-1.821608E-01	-3.393099E-02
CMQ	3.25012E-01	-5.232541E-02	CMQ	-1.491636E-01	-2.006387E-01	CMQ	1.234104E+00	7.327591E-01
CMQ			CMQ			CMQ	7.327591E-01	5.576479E-02

# ALGORITHM PRINTOUT - Continued

RUN= 1 PASS= 5 DET1= 1.225144E+28 DET2= 3.483735E-07 AJP= 1.840700E+03

ACTIVE ALGORITHM VARIABLES ARE . . . U .M .Q .THE

PACKED MEAN ARRAY

-5.6360E-03 -6.9424E-02 3.2014E-04 1.2667E-03

PACKED NOISE COVARIANCE MATRIX

2.4535E-01 4.0423E-02 -4.3564E-04 -1.0238E-03  
4.0423E-02 8.9116E+00 -2.8405E-03 -1.2668E-03  
-4.3564E-04 -2.8405E-03 3.9910E-04 5.3289E-06  
-1.0238E-03 -1.2668E-03 5.3289E-06 3.5881E-04

PACKED WEIGHT MATRIX

4.0613E+00 0. 0. 0.  
0. 1.1236E-01 0. 0.  
0. 0. 2.5054E+03 0.  
0. 0. 0. 2.5108E+03

PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE
U0	2.099000E+02	0.	CX0	1.100850E-01	1.171584E-05	CXAL	0.	0.
CX0	0.	0.	THE0	8.000000E-02	0.	PHI0	0.	0.
W0	5.000000E+00	0.	CZ0	-1.289196E+00	2.408599E-05	CZAL	-4.435563E+00	2.265796E-04
CZ0	0.	0.	CZDE	-4.925352E+00	-3.311509E-03	Q0	0.	0.
CM0	1.959712E-02	2.683831E-06	CMAL	-8.216578E-01	4.584780E-05	CMALD	0.	0.
CMQ	-3.279227E+01	-6.166114E-03	CMDE	-3.085628E+00	-7.090331E-04	V0	0.	0.
CY0	0.	0.	CY8	0.	0.	CY8D	0.	0.
CYP	0.	0.	CYR	0.	0.	CYDR	0.	0.
PO	0.	0.	CLO	0.	0.	CLB	0.	0.
CL80	0.	0.	CLP	0.	0.	CLR	0.	0.
CLDR	0.	0.	CLDA	0.	0.	RO	0.	0.
CND	0.	0.	CNB	0.	0.	CNBD	0.	0.
CNP	0.	0.	CNR	0.	0.	CNDR	0.	0.
CNDA	0.	0.						

MODIFIED PARAMETER COVARIANCE MATRIX

PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE
CX0	1.738483E-03	9.391422E-02	CZAL	-3.195700E-01	-7.364319E-01	CMQ	7.949339E-02	7.949339E-02
CZ0	9.391422E-02	7.817465E-03	CZDE	-2.590370E-02	6.760020E-01	CMAL	2.597771E-01	4.433490E-01
CZAL	-3.195700E-01	-7.042597E-01	CMDE	-2.396086E-01	-1.802678E-01	CMDE	3.238534E-01	3.238534E-01
CZDE	-7.364319E-01	-2.590370E-02	CMAL	-3.934699E-01	-1.802678E-01			
CM0	7.949339E-02	6.760020E-01	CMDE	-3.934699E-01	-1.802678E-01			
CMAL	2.597771E-01	4.433490E-01	CMDE	-3.934699E-01	-1.802678E-01			
CMQ	4.433490E-01	3.072261E-01	CMDE	-3.934699E-01	-1.802678E-01			
CMDE	3.238534E-01	-5.343510E-02	CMDE	-3.934699E-01	-1.802678E-01			

CXO	CZO	CZAL	CZDE	CMO	CMAL	CMQ	CMDE
1.379191E-03	9.3378918E-02	-3.7115967E-01	-7.368262E-01	7.917586E-02	2.603217E-01	4.432652E-01	3.237067E-01
9.379918E-02	7.820372E-03	-7.042382E-01	-2.575957E-01	6.761157E-01	2.256903E-02	3.070543E-01	-5.3367571E-02
3.195967E-01	-7.042382E-01	2.2320846E-01	3.639507E-01	-1.513518E-01	2.859480E-02	-6.420889E-01	-1.485731E-01
7.368262E-01	-2.755957E-02	3.639507E-01	4.090537E-01	3.787074E-01	-6.422944E-01	-2.395796E-01	-1.998065E-01
7.917586E-02	6.761157E-01	-1.513518E-01	3.787074E-01	8.053718E-04	3.930200E-01	7.312701E-02	-4.9494297E-02
2.603217E-01	2.256903E-02	2.859480E-02	-6.42944E-01	3.930200E-01	1.654742E-02	-1.801388E-01	-3.252243E-02
4.432652E-01	3.070543E-01	-6.420889E-01	-2.395796E-01	7.312701E-02	1.801388E-01	1.231299E+00	7.327137E-01
3.237067E-01	-5.3367571E-02	-1.485731E-01	-1.998065E-01	-4.9494297E-02	-3.252243E-02	7.327137E-01	5.583926E-02

# ALGORITHM PRINTOUT -- Continued

RUN= 1 PASS= 7 DET1= 1.231219E+28 DET2= 3.480109E-07 AJP= 1.840966E+03

ACTIVE ALGORITHM VARIABLES ARE . . . U ,W ,Q ,THE

PACKED MEAN ARRAY

-5.4923E-C3 -7.0646E-02 3.2065E-04 1.2681E-C3

PACKED NOISE COVARIANCE MATRIX

2.4530E-01 4.0312E-02 -4.3630E-04 -1.0229E-C3  
4.0312E-02 8.9129E+00 -2.8431E-03 -1.2617E-C3  
-4.3630E-04 -2.8431E-C3 3.9910E-04 5.3471E-05  
-1.0229E-C3 -1.2617E-03 5.3471E-06 3.9883E-04

PACKED WEIGHT MATRIX

4.C765E+00 0. 0. 0.  
0. 1.1220E-01 0. 0.  
0. 0. 2.5056E+C3 0.  
0. 0. 0. 2.5074E+03

PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE
UO	2.09000E+C2	0.	CXG	1.100969E-01	1.484661E-07	CXAL	0.	0.	PHIO	0.	0.
CXO	0.	0.	THEO	8.00000E-02	0.	CZAL	-4.435423E+00	-6.973652E-06			
WO	5.00030E+00	0.	CZO	-1.289164E+00	4.264216E-07	QO	0.	0.			
CZO	0.	0.	CZOE	-4.928978E+00	-3.802998E-05	QO	0.	0.			
CMO	1.960001E-02	2.126416E-08	CPAL	-8.216017E-01	8.095074E-07	CMALD	0.	0.			
CMQ	-3.279954E+01	6.565506E-07	CPDE	-3.086472E+00	-5.074042E-06	VO	0.	0.			
CYO	0.	0.	CYB	0.	0.	CYBD	0.	0.			
CYP	0.	0.	CYR	0.	0.	CYDR	0.	0.			
PO	0.	0.	CLD	0.	0.	CLB	0.	0.			
CLBD	0.	0.	CLP	0.	0.	CLR	0.	0.			
CLDR	0.	0.	CLDA	0.	0.	RO	0.	0.			
CNO	0.	0.	CNB	0.	0.	CNBD	0.	0.			
CNP	0.	0.	CNR	0.	0.	CNDR	0.	0.			
CNDA	0.	0.									

MODIFIED PARAMETER COVARIANCE MATRIX

PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE
CXO	1.739249E-C3	9.378442E-02	CZAL	-3.1196039E-01	-7.368498E-01	CMO	7.915952E-02	2.603425E-01	CMQ	4.432581E-01	3.236864E-01
CZO	9.378442E-02	7.820765E-03	CMO	-2.574102E-02	6.761395E-01	CMQ	3.070266E-01	3.070266E-01	CMDE	-5.369023E-02	-5.369023E-02
CZAL	-3.1196039E-01	-7.042255E-01	CZDE	-2.574102E-02	6.761395E-01	CMDE	-6.420834E-01	-6.420834E-01			
CZDE	-7.368498E-01	-2.574102E-02	CMO	3.639332E-01	-1.513695E-01						
CMO	7.915952E-02	6.761395E-01	CMQ	3.639332E-01	3.787009E-01						
CMAL	2.603425E-01	2.257722E-02	CMDE	-6.420834E-01	8.053897E-04						
CMQ	4.432581E-01	3.070266E-01									
CMDE	3.236864E-01	-5.369023E-02									

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RUN= 1 PASS= 8 DET1= 1.231248E+28 DET2= 3.480108E-07 AJP= 1.840969E+03

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ACTIVE ALGORITHM VARIABLES ARE . . . U , W , Q , THE

PACKED MEAN ARRAY

-5.4913E-03 -7.0656E-02 3.2065E-04 1.2681E-03

PACKED NOISE COVARIANCE MATRIX

PACKED NOISE MATRIX			
2.4530E-01	4.0311E-02	4.3630E-04	-1.0229E-03
2.4530E-02	8.9130E+00	-2.8431E-03	-1.2617E-03
4.0311E-02	-2.8431E-03	3.9910E-04	5.3472E-06
-4.3630E-04	1.2617E-03	5.3472E-06	3.9883E-04
-1.0229E-03	-1.2617E-03	3.9883E-04	

## PACKED WEIGHT MATRIX

PACKED WEIGHT MATRIX					
4.0766E+00	0.	0.	0.	0.	0.
0.	1.1220E-01	0.	0.	0.	0.
0.	0.	2.5056E+03	0.	0.	0.
0.	0.	0.	2.5073E+03	0.	0.

PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE
PARAM			PARAM			PARAM		
UO	2.099000E+02	0.	CXO	1.100970E-01	-1.711795E-09	CXAL	0.	0.
CXO	0.	0.	TFEO	8.000000E-02	0.	PHIO	0.	0.
WO	5.000000E+00	0.	CZO	-1.289164E+00	1.038340E-07	CZAL	-4.435430E+00	-1.972368E-06
CZO	0.	0.	CZDE	-4.929016E+00	-2.661941E-06	QO	0.	0.
CWO	1.963004E-02	1.522098E-09	CVAL	-8.216009E-01	1.095917E-07	CMALD	0.	0.
CMO	-3.279954E+01	-6.122211E-06	CWDE	-3.086477E+00	-1.257595E-06	VO	0.	0.
CVO	0.	0.	CVB	0.	0.	CYBD	0.	0.
CYP	0.	0.	CYR	0.	0.	CYDR	0.	0.
PO	0.	0.	CLO	0.	0.	CLB	0.	0.
CLBO	0.	0.	CLP	0.	0.	CLR	0.	0.
CLDR	0.	0.	CLOA	0.	0.	RO	0.	0.
CNO	0.	0.	CNB	0.	0.	CNBD	0.	0.
CNP	0.	0.	CNR	0.	0.	CNDR	0.	0.

MODIFIED PARAMETER COVARIANCE MATRIX

CXO	CZO	CZAL	CZDE	CMO	CMAL	CMQ	CMDE
1.739259E-03	9.378277E-02	-3.196033E-01	-7.368533E-01	7.515719E-02	2.6033460E-01	4.332571E-01	3.236844E-01
9.739277E-02	7.820808E-03	-7.042247E-01	-2.757394E-02	6.761415E-01	2.257765E-02	3.072046E-01	-5.369297E-02
3.196037E-01	-7.042247E-01	2.230863E-01	3.639322E-01	-1.513710E-01	2.861534E-02	-6.420838E-01	-1.4856638E-01
-7.368533E-01	-2.573942E-02	3.639322E-01	4.906595E-01	3.786996E-01	-6.829489E-01	-2.395631E-01	-4.947859E-01
7.915719E-02	6.761415E-01	-1.513710E-01	3.786995E-01	8.053911E-04	3.929879E-01	7.312011E-02	-1.982676E-02
2.6033460E-01	2.257765E-02	2.861534E-02	-6.429489E-01	-3.929879E-01	1.534754E-02	-1.8021558E-01	-3.254106E-02
4.432371E-01	3.072046E-01	-6.420838E-01	2.739631E-01	7.312011E-02	-1.591558E+00	1.231295E+00	7.327144E-01
3.236844E-01	-5.369297E-02	-1.485663E-01	-1.997859E-01	-4.947859E-02	-3.254106E-02	7.327144E-01	5.584104E-02

# ALGORITHM PRINTOUT - Continued

RUN= 1 PASS= 9 DET1= 1.231248E+28 DET2= 3.480108E-07 AJP= 1.840969E+03

ACTIVE ALGORITHM VARIABLES ARE . . . U .M .C .THE

PACKED MEAN ARRAY

-5.4911E-03 -7.0658E-02 3.2065E-04 1.2682E-03

PACKED NOISE COVARIANCE MATRIX

2.4530E-01 4.0311E-02 -4.3630E-04 -1.0222E-C3  
4.0311E-02 8.9130E+00 -2.8431E-03 -1.2617E-C3  
-4.3630E-04 -2.8431E-C3 3.9910E-04 5.3472E-C6  
-1.0222E-03 -1.2617E-03 5.3472E-06 3.9883E-04

PACKED WEIGHT MATRIX

4.0766E+00 0.  
0. 1.1220E-01 0.  
0. 0. 2.5056E+C3 0.  
0. 0. 0. 2.5073E+03

PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE
UO	2.099000E+02	0.	CXO	1.100970E-01	1.801348E-09	CXAL	0.	0.
CXO	0.	0.	TPEO	8.000000E-02	0.	PHIO	0.	0.
WO	5.000000E+00	0.	CZO	-1.289164E+00	5.727104E-09	CZAL	-4.435432E+00	-1.434817E-07
CZO	0.	0.	CZDE	-4.929019E+00	-4.083731E-07	QO	0.	0.
CMD	1.960004E-02	2.537085E-10	CVAL	-8.216008E-01	7.563177E-09	CMALO	0.	0.
CMD	-3.279954E+01	5.222571E-07	CMDE	-3.086478E+00	-3.447917E-08	VO	0.	0.
CYO	0.	0.	CYB	0.	0.	CYD	0.	0.
CYP	0.	0.	CYR	0.	0.	CYDR	0.	0.
PO	0.	0.	CLO	0.	0.	CLB	0.	0.
CLBD	0.	0.	CLP	0.	0.	CLR	0.	0.
CLDR	0.	0.	CLDA	0.	0.	RO	0.	0.
CND	0.	0.	CNB	0.	0.	CNBD	0.	0.
CNP	0.	0.	CNR	0.	0.	CNDR	0.	0.
CNDA	0.	0.						

MODIFIED PARAMETER COVARIANCE MATRIX

PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE
CXO	1.739260E-03	9.378271E-02	CZAL	-3.196037E-01	-7.368535E-01	CMO	7.915708E-02	4.432570E-01
CZO	9.378271E-02	7.820813E-03	CZO	-7.042245E-01	-2.573921E-02	CMQ	3.070243E-01	3.236841E-01
CZAL	-3.196037E-01	-7.042245E-01	CZDE	2.230863E-01	3.639320E-01	CMAL	2.257755E-02	-5.369310E-02
CZDE	-7.368535E-01	-2.573921E-02	CMO	3.639320E-01	4.090660E-01	CMQ	-6.429838E-01	-1.485637E-01
CMO	7.915708E-02	6.761419E-01	CMQ	-1.513713E-01	8.053913E-04	CMAL	-6.429838E-01	-1.997856E-01
CMAL	2.603461E-01	2.257755E-02	CMQ	2.861584E-02	-6.429838E-01	CMAL	-3.929877E-01	-4.942564E-02
CMQ	4.432570E-01	3.070243E-01	CMQ	-6.429838E-01	-2.395629E-01	CMQ	1.801563E-01	-3.254147E-02
CMDE	3.236841E-01	-5.369310E-02	CMQ	-1.485637E-01	-1.997856E-01	CMQ	1.231295E+00	7.327144E-01
						CMQ	7.327144E-01	5.584105E-02

## 92

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RUN= 1 PASS= 10 DET1= 1.231249E+28 DET2= 3.480108E-07 AJP= 1.840969E+03

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ACTIVE ALGORITHM VARIABLES ARE . . . U , W , Q , THE

### PACKED MEAN ARRAY

5.4911E-03 -7.0658E-02 3.2065E-04 1.2682E-03

PACKED NOISE COVARIANCE MATRIX

2.4530E-01 4.0311E-02 -4.3630E-04 -1.0229E-03

4.0311E-02 8.9130E+00 -2.8431E-03 -1.2617E-03

4.3630E-04 -2.8431E-03 3.9910E-04 5.3472E-06

1.0229E-03 -1.2617E-03 5.3472E-06 3.9883E-04

PACKED WEIGHT MATRIX

4.0766E+00 0. 0.

0. 1.1220E-01 0. 0.

0. 0. 2.5056E+03 0.

PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE
PARAM	VALUE	CHANGE	PARAM	VALUE	CHANGE

	DATE	TIME	VALUE	CXAL	VALVE	CORROSE	
UO	2.099000E+02	0.	CX0	1.100970E-01	-6.047394E-11	CXAL	0.

CXO	0.		0.	TAE0	8.000000E-02	0.	PDI0	0.
CXO	0.		0.				PDI0	0.

0000	5.000000E+00	0.	CZ0	-1.289164E+00	1.224886E-09	CZAL	-4.435432E+00	-2.711614E-
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CZ0	0.	CZDE	-4.929019E+00	-2.001313E-08	0.	0.
CZ0	0.					

CMO	CMAL	CMALD	0.
1.960094E-02	1.147357E-11	-8.216008E-01	1.013162E-C9
CMO			0.

CMQ	-3.279954E+01	-4.039551E-08	CMDE	-3.086478E+00	-1.272922E-08	VD.	0.
CMQ	-3.279954E+01	-4.039551E-08	CMDE	-3.086478E+00	-1.272922E-08	VD.	0.

Genotype	Control	100 mg/kg	200 mg/kg	400 mg/kg	800 mg/kg
CYD	0.0	0.0	0.0	0.0	0.0
CYB	0.0	0.0	0.0	0.0	0.0
CY8D	0.0	0.0	0.0	0.0	0.0
CY8B	0.0	0.0	0.0	0.0	0.0

[illegible]

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[illegible][illegible]

Case	Age	Sex	Duration	Site	Pathology	Response	Survival
1	65	M	10 years	Rectum	Adenocarcinoma	CR	5 years
2	58	F	8 years	Colon	Adenocarcinoma	CR	3 years
3	72	M	12 years	Rectum	Adenocarcinoma	CR	4 years
4	60	F	9 years	Colon	Adenocarcinoma	CR	2 years
5	68	M	11 years	Rectum	Adenocarcinoma	CR	6 years
6	55	F	7 years	Colon	Adenocarcinoma	CR	1 year
7	70	M	13 years	Rectum	Adenocarcinoma	CR	3 years
8	62	F	9 years	Colon	Adenocarcinoma	CR	2 years
9	66	M	10 years	Rectum	Adenocarcinoma	CR	4 years
10	59	F	8 years	Colon	Adenocarcinoma	CR	1 year

MODIFIED PARAMETER COVARIANCE MATRIX

CXO	CZO	CZAL	CZDE	CMQ	CMDF
				CMAL	

CX0	1.739260E-03	9.378269E-02	-3.196037E-01	-7.368535E-01	7.915706E-02	2.603461E-01	4.432570E-01	3.236841E-01
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9.378269E-02	7.82C814E-03	-7.042245E-01	-2.573919F-02	6.761419E-01	2.257754E-02	3.070243E-01	-5.369313E-02
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CZAL	-3.196037E-01	-7.042245E-01	2.230863E-01	3.639320E-01	-1.513713E-01	2.861588E-02	-6.427938E-01	-1.485637E-01
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CZDE	-7.363535E-01	-2.573919E-02	3.639320E-01	4.090660E-01	3.786994E-01	-6.429488E-01	-2.395629E-01	-1.997856E-01
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CMO	7.915706E-02	6.761419E-01	-1.513713E-01	3.786994E-01	8.053913E-04	-3.929876E-01	7.312017E-02	-4.942664E-02
CMO	7.915706E-02	6.761419E-01	-1.513713E-01	3.786994E-01	8.053913E-04	-3.929876E-01	7.312017E-02	-4.942664E-02

CMAL	2.603461E-01	2.257754E-02	2.861588E-02	-6.429488E-01	-3.929876E-01	1.654755E-02	-1.801564E-01	-3.254150E-02
NO	1.122570E-01	3.078212E-01	1.110002E-01	3.205120E-01	7.510017E-01	1.081573E-01	3.021843E-01	7.021843E-01

	0	1	2	3	4	5	6	7	8	9
CHQ	4.43257E-01	3.070243E-01	-6.420838E-01	-2.395629E-01	7.312017E-02	-1.801564E-01	1.231295E+03	7.377144E-01		
CNF	2.236941E-01	-5.349212E-02	-1.495427E-01	-1.837854E-01	-4.842444E-02	-3.254150E-02	7.227174E-01	5.591305E-02		

LMUE	3.0236841E-01	-3.369313E-02	-1.482637E-01	-1.971836E-01	-4.942664E-02	-3.0234150E-02	1.327144E-01	3.584105E-01
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## CONCLUDING REMARKS

A computer program has been developed for estimating aircraft stability and control parameters from flight test data. The maximum likelihood estimation program has been implemented on the Langley real-time simulation system. The control and display capabilities of the system allow the analyst to interact with the program. The interactive capability is highly desirable, as evident in the reports on the analysis of flight test data. Variable dimensioning allows the analyst to activate any part of the nonlinear six-degree-of-freedom aircraft mathematical model, select the variables in the performance index function, and choose which parameters are to be estimated. Although this report uses a particular aircraft example, it is applicable to any dynamic system fitting into the framework of the program.

Langley Research Center,  
National Aeronautics and Space Administration,  
Hampton, Va., May 9, 1973.

## APPENDIX A

### PROGRAM CONTROL AND DISPLAY CAPABILITIES

The computer program has been written in FORTRAN IV (75,000 octal locations) and run on the RTS system of the Control Data series 6000 digital computer complex. The computer program was mechanized into an iterative estimation procedure with manual interactive control and graphic display capabilities through the utilization of the RTS system. Figure 3(a) shows a photograph of the program control station and figure 3(b) shows a closeup of the control panel. The components are listed below as they appear (left to right) in figure 3:

#### Program control station:

##### Graphic display unit

- Cathode ray tube (CRT)

- Interactive keyboard

##### Time history recorder

- x-y plotter (not used)

##### Control console

- White indicator lights (WL)

- Red indicator lights, bottom row (not used)

- Function sense switches (FSS)

- Mode control switches

- Data entry keyboard

- Digital decimal display unit (DDDU)

- Potentiometers (not used)

- Output device (typewriter)

The CRT displays the flight test maneuver at the start of each iteration. The response of the equations of motion as it is computed in the digital program is plotted with the flight test maneuver for direct comparison. This display permits quick analysis of each flight test case on an iteration to iteration basis. Figure 4 shows CalComp plots representing three CRT displays; they are part of the dynamic check.

The analyst investigating the stability and control derivatives of the aircraft has direct control of the computer program through the control console. The white indicator lights (WL(1) - WL(39)) are used to indicate program status or diagnostics. The diagnostics are described in the LDISO array of the Display Arrays section. The function sense switches (FSS(1) to FSS(16)) are used to select program options (switch depressed results in logical true value). The options are described in the LDISI array of the Display Arrays section.

## APPENDIX A – Continued

The mode control keyboard (shown below) is used to control the running of the RTS computer program.

OPER	HOLD	RESET	TERM
CHANGE	SCAN	RELEASE	
		ERASE	
IDLE	READ	PRINT	RELEASE

Each switch (mode) is briefly described as to its use (mode nominally active when switch depressed):

**OPER (OPERATE)** – allows normal running of parameter estimation procedure (integration of equations of motion and sensitivity equations)

**HOLD** – holds estimation procedure at last time point (stops integration)

**RESET** – initializes estimation procedure at  $t = 0$

**TERM (TERMINATE)** – terminates program at control console and transfers control to graphic display unit

Activation of one mode automatically deactivates the previous one. The following modes are temporarily activated by the analyst during the parameter estimation study (normally when in RESET or HOLD modes):

**CHANGE** – changes program variable to the new value entered on the data entry keyboard and displayed on the DDDU

**SCAN** – scans through the display addresses in conjunction with subroutine SCANNER

**RELEASE** – releases CHANGE and SCAN modes

**ERASE** – erases real-time disk file

## APPENDIX A – Continued

**IDLE** – idles the computer (no computations)

**READ** – loads read overlay

**PRINT** – loads print overlay

**RELEASE** – releases the four preceding modes

The data entry keyboard (shown below) is used to input new values for program variables.

0	1	2	3
4	5	6	7
8	9	DECIMAL POINT	(-)
TAB	CR	ERASE	CR

The keyboard is used in conjunction with the DDDU (shown below).

(Address field)			(Magnitude field)					(Exponent field)		
A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	±	.	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	M <sub>4</sub>	M <sub>5</sub>	± E <sub>1</sub> E <sub>2</sub>

The procedure for changing a floating-point number is as follows:

- (1) Enter address field – A<sub>1</sub> A<sub>2</sub> A<sub>3</sub>
- (2) Depress TAB
- (3) Enter magnitude field – ± . M<sub>1</sub> M<sub>2</sub> M<sub>3</sub> M<sub>4</sub> M<sub>5</sub>
- (4) Depress TAB
- (5) Enter exponent field – ± E<sub>1</sub> E<sub>2</sub>
- (6) Depress TAB

## APPENDIX A - Concluded

(7) Depress **CR**

(8) Depress **CHANGE**

(9) Depress **RELEASE**

As the numbers and signs (plus sign assumed) are entered on the keyboard, they are displayed on the DDDU. The DDDU shows the final form of the number entered by the keyboard. Integers and logical variables are entered in a similar manner but with a different format. The switches **ERASE** and **CR** are used to erase the data field and character just entered, respectively.

The typewriter is used to type out the new and old values of the program variables. The time history recorder plots the variables defined in the DAC array (Display Arrays section). The interactive keyboard is used to restart and exit the program from the RTS system. A card reader and high-speed printer are located near the program control station and are easily accessible to the program operator.

## APPENDIX B

### EQUATIONS OF MOTION AND ACCELEROMETER EQUATIONS

The mathematical model is that of a nonlinear six-degree-of-freedom rigid-body aircraft, in particular, a V/STOL tilt-wing aircraft. The equations of motion are

$$\begin{aligned}\dot{\vec{x}} &= F(\vec{x}, \vec{\alpha}, \vec{\delta}, V, \alpha_a, \dot{\alpha}_a, \beta, \dot{\beta}) \\ &= [F_1, F_2, \dots, F_8]^T\end{aligned}\tag{B1}$$

The state vector is

$$\begin{aligned}\vec{x} &= [x_1, x_2, \dots, x_8]^T \\ &= [u, v, w, p, q, r, \theta, \phi]^T\end{aligned}\tag{B2}$$

The parameter vector is

$$\begin{aligned}\vec{\alpha} &= [\alpha_1, \alpha_2, \dots, \alpha_{40}]^T \\ &= [u(0), (C_X)_{\alpha_a, t}, \delta_{e, t}, \dots, C_{n_{\delta_a}}]^T\end{aligned}\tag{B3}$$

The control deflection vector is

$$\vec{\delta} = [\delta_a, \delta_e, \delta_r]^T\tag{B4}$$

The equations of motion in detail are

$$\begin{aligned}\dot{u} &= F_1(\vec{x}, \vec{\alpha}, \vec{\delta}, V, \alpha_a) \\ &= -qw + rv - g \sin \theta + a_1 V^2 (C_{X1} + C_{X2}) + \frac{T_X}{m}\end{aligned}\tag{B5}$$

APPENDIX B – Continued

$$\begin{aligned}\dot{v} &= F_2(\bar{x}, \bar{\alpha}, \bar{\delta}, V, \beta) \\ &= \frac{-ru + pw + g \cos \theta \sin \phi + a_1 V^2 (C_{Y1} + C_{Y2}) + \frac{T_Y}{m}}{1 - a_3 C_{Y\dot{\beta}}}\end{aligned}\quad (B6)$$

$$\begin{aligned}\dot{w} &= F_3(\bar{x}, \bar{\alpha}, \bar{\delta}, V, \alpha_a) \\ &= -pv + qu + g \cos \theta \cos \phi + a_1 V^2 (C_{Z1} + C_{Z2}) + \frac{T_Z}{m}\end{aligned}\quad (B7)$$

$$\begin{aligned}\dot{p} &= F_4(\bar{x}, \bar{\alpha}, \bar{\delta}, V, \beta, \dot{\beta}) \\ &= a_6 F'_4(\bar{x}, \bar{\alpha}, \bar{\delta}, V, \beta, \dot{\beta}) + b_1 F'_6(\bar{x}, \bar{\alpha}, \bar{\delta}, V, \beta, \dot{\beta}) \\ &= a_6 \left[ b_2 qr + I_{XZ} pq + a_4 V^2 (C_{l1} + C_{l2}) + a_4 V_S^2 (C_{l3}) + M_X \right] \\ &\quad + b_1 \left[ b_3 pq - I_{XZ} qr + a_4 V^2 (C_{n1} + C_{n2}) - a_4 V_S^2 (C_{n3}) + M_Z \right]\end{aligned}\quad (B8)$$

$$\begin{aligned}\dot{q} &= F_5(\bar{x}, \bar{\alpha}, \bar{\delta}, V, \alpha_a, \dot{\alpha}_a) \\ &= a_7 pr + b_4 (r^2 - p^2) + a_8 V^2 (C_{m1} + C_{m2}) + \frac{M_Y}{I_Y}\end{aligned}\quad (B9)$$

$$\begin{aligned}\dot{r} &= F_6(\bar{x}, \bar{\alpha}, \bar{\delta}, V, \beta, \dot{\beta}) \\ &= b_1 F'_4(\bar{x}, \bar{\alpha}, \bar{\delta}, V, \beta, \dot{\beta}) + b_5 F'_6(\bar{x}, \bar{\alpha}, \bar{\delta}, V, \beta, \dot{\beta})\end{aligned}\quad (B10)$$

$$\begin{aligned}\dot{\theta} &= F_7(\bar{x}) \\ &= q \cos \phi - r \sin \phi\end{aligned}\quad (B11)$$

# APPENDIX B - Continued

$$\begin{aligned}\dot{\phi} &= F_8(\bar{x}) \\ &= p + (q \sin \phi + r \cos \phi) \tan \theta\end{aligned}\tag{B12}$$

where

$$\begin{aligned}a_1 &= \frac{1}{2} \frac{\rho}{m} S & a_2 &= a_1 \left( \frac{\bar{c}}{2} \right) & a_3 &= a_1 \left( \frac{b}{2} \right) \\ a_4 &= \frac{1}{2} \rho S b & a_5 &= a_4 \left( \frac{b}{2} \right) & a_6 &= \frac{I_Z}{I_X I_Z - I_{XZ}^2} \\ a_7 &= \frac{I_Z - I_X}{I_Y} & a_8 &= \frac{1}{2} \frac{\rho}{I_Y} S \bar{c} & a_9 &= a_8 \left( \frac{\bar{c}}{2} \right) \\ b_1 &= \frac{I_{XZ}}{I_X I_Z - I_{XZ}^2} & b_2 &= I_Y - I_Z & b_3 &= I_X - I_Y \\ b_4 &= \frac{I_{XZ}}{I_Y} & b_5 &= \frac{I_X}{I_X I_Z - I_{XZ}^2}\end{aligned}$$

and

$$V_S = V_{SS} + V$$

$$\begin{aligned}C_{X1} &= (C_X)_{\alpha_{a,t}, \delta_{e,t}} + C_{X\alpha_a} (\alpha_a - \alpha_{a,t}) & C_{X2} &= C_{Xq} \frac{q\bar{c}}{2V} \\ C_{Y1} &= (C_Y)_{\beta_t, \delta_{a,t}, \delta_{r,t}} + C_{Y\beta} (\beta - \beta_t) + C_{Y\delta_r} (\delta_r - \delta_{r,t}) & C_{Y2} &= \frac{b}{2V} (C_{Yp} p + C_{Yr} r) \\ C_{Z1} &= (C_Z)_{\alpha_{a,t}, \delta_{e,t}} + C_{Z\alpha_a} (\alpha_a - \alpha_{a,t}) + C_{Z\delta_e} (\delta_e - \delta_{e,t}) & C_{Z2} &= C_{Zq} \frac{q\bar{c}}{2V} \\ C_{l1} &= (C_l)_{\beta_t, \delta_{a,t}, \delta_{r,t}} + C_{l\beta} (\beta - \beta_t) + C_{l\delta_r} (\delta_r - \delta_{r,t}) & C_{l2} &= \frac{b}{2V} (C_{l\beta} \dot{\beta} + C_{lp} p + C_{lr} r) \\ C'_{l\delta_a} &= C_{l\delta_a} \cos i_w - C_{n\delta_a} \sin i_w & C_{l3} &= C'_{l\delta_a} (\delta_a - \delta_{a,t}) \\ C_{m1} &= (C_m)_{\alpha_{a,t}, \delta_{e,t}} + C_{m\alpha_a} (\alpha_a - \alpha_{a,t}) + C_{m\delta_e} (\delta_e - \delta_{e,t}) & C_{m2} &= \frac{\bar{c}}{2V} (C_{m\alpha_a} \dot{\alpha}_a + C_{mq} q) \\ C_{n1} &= (C_n)_{\beta_t, \delta_{a,t}, \delta_{r,t}} + C_{n\beta} (\beta - \beta_t) + C_{n\delta_r} (\delta_r - \delta_{r,t}) & C_{n2} &= \frac{b}{2V} (C_{n\beta} \dot{\beta} + C_{np} p + C_{nr} r) \\ C'_{n\delta_a} &= C_{l\delta_a} \sin i_w + C_{n\delta_a} \cos i_w & C_{n3} &= C'_{n\delta_a} (\delta_a - \delta_{a,t})\end{aligned}$$

## APPENDIX B - Continued

The auxiliary equations are

$$\left. \begin{aligned} \dot{\psi} &= \frac{q \sin \phi + r \cos \phi}{\cos \theta} \\ V &= \sqrt{u^2 + v^2 + w^2} \\ \alpha_a &= \tan^{-1} \frac{w}{u} \\ \dot{\alpha}_a &\approx \frac{\dot{w}}{u} \\ \beta &= \sin^{-1} \frac{v}{V} \\ \dot{\beta} &\approx \frac{\dot{v}}{V} \\ V_{SS} &= \frac{8}{\pi} \eta_E^2 D_E^2 C_T \end{aligned} \right\} \quad (B13)$$

The trim conditions are

$$\alpha_{a,t} = \begin{cases} \text{ALPHAT or} \\ \tan^{-1} \frac{w(0)}{u(0)} \end{cases}$$

$$\beta_t = 0$$

$$\delta_{a,t} = \text{DABIAS}$$

$$\delta_{e,t} = \text{DEBIAS}$$

$$\delta_{r,t} = \text{DRBIAS}$$

## APPENDIX B - Continued

The thrust and moment equations are known inputs (flight test data and constants) to the equations of motion.

$$\left. \begin{aligned}
 T_X &= 4\rho\eta_E^2 D_E^4 C_T \cos i_w \\
 T_Y &= 0 \\
 T_Z &= -4\rho\eta_E^2 D_E^4 C_T \sin i_w - \rho\eta_T^2 D_T^4 C_{TT} \\
 M_X &= 2\rho\eta_E^2 D_E^4 \bar{l} C_{TB} \overline{\delta B} \sin i_w \\
 M_Y &= -4\rho\eta_E^2 D_E^4 r_b C_T - \rho\eta_T^2 D_T^4 l_{TP} C_{TT} \\
 M_Z &= 2\rho\eta_E^2 D_E^4 \bar{l} C_{TB} \overline{\delta B} \cos i_w
 \end{aligned} \right\} \quad (B14)$$

where

$$C_T = C_{T,o} + C_{TB} \overline{\Delta B}$$

$$C_{TT} = C_{TT_o} + C_{T\beta_T} \beta_T$$

$$\eta_E = \frac{1232}{60} P_E$$

$$\eta_T = \frac{2400}{60} P_T$$

The accelerometer measurements and equations were included in the parameter estimation algorithm to improve the extraction process. They are used with or can replace the linear velocities  $u$ ,  $v$ , and  $w$ . The accelerometer equations were transformed to the instrument location from the center of gravity (ref. 6).

# APPENDIX B – Concluded

$$\begin{aligned} \vec{a}_I &= \begin{bmatrix} a_{X,I} \\ a_{Y,I} \\ a_{Z,I} \end{bmatrix} \\ &= \frac{1}{g} \begin{bmatrix} \dot{u} + qw - rv + g \sin \theta \\ \dot{v} + ru - pw - g \cos \theta \sin \phi \\ \dot{w} + pv - qu - g \cos \theta \cos \phi \end{bmatrix} + \frac{1}{g} \begin{bmatrix} -(q^2 + r^2)x_X + (pq - \dot{r})y_X + (pr + \dot{q})z_X \\ (pq + \dot{r})x_Y - (p^2 + r^2)y_Y + (qr - \dot{p})z_Y \\ (pr - \dot{q})x_Z + (qr + \dot{p})y_Z - (p^2 + q^2)z_Z \end{bmatrix} \quad (B15) \end{aligned}$$

The accelerometer equations need only to be evaluated and not integrated.

## APPENDIX C

### SENSITIVITY EQUATIONS AND ACCELEROMETER

#### SENSITIVITY COEFFICIENTS

The sensitivity equations for the method of quasilinearization are presented in detail for the equations of motion presented in appendix B.

The sensitivity equations are

$$\begin{aligned}
 \frac{d}{dt} \left( \frac{\partial \vec{x}}{\partial \alpha_i} \right) &= \left( \frac{\partial \dot{\vec{x}}}{\partial \alpha_i} \right) \\
 &= \left\{ \sum_{k=1}^8 \frac{\partial \vec{F}}{\partial \mathbf{x}_k} \left( \frac{\partial \mathbf{x}_k}{\partial \alpha_i} \right) + \frac{\partial \vec{F}}{\partial V} \sum_{k=1}^3 \frac{\partial V}{\partial \mathbf{x}_k} \left( \frac{\partial \mathbf{x}_k}{\partial \alpha_i} \right) + \frac{\partial \vec{F}}{\partial \alpha_a} \sum_{k=1}^3 \frac{\partial \alpha_a}{\partial \mathbf{x}_k} \left( \frac{\partial \mathbf{x}_k}{\partial \alpha_i} \right) \right. \\
 &\quad \left. + \frac{\partial \vec{F}}{\partial \dot{\alpha}_a} \frac{\partial \dot{\alpha}_a}{\partial \mathbf{x}_1} \left( \frac{\partial \mathbf{x}_1}{\partial \alpha_i} \right) + \frac{\partial \vec{F}}{\partial \beta} \left[ \frac{\partial \beta}{\partial \mathbf{x}_2} \left( \frac{\partial \mathbf{x}_2}{\partial \alpha_i} \right) + \frac{\partial \beta}{\partial V} \sum_{k=1}^3 \frac{\partial V}{\partial \mathbf{x}_k} \left( \frac{\partial \mathbf{x}_k}{\partial \alpha_i} \right) \right] \right. \\
 &\quad \left. + \frac{\partial \vec{F}}{\partial \dot{\beta}} \frac{\partial \dot{\beta}}{\partial V} \sum_{k=1}^3 \frac{\partial V}{\partial \mathbf{x}_k} \left( \frac{\partial \mathbf{x}_k}{\partial \alpha_i} \right) \right\} + \left[ \frac{\partial \vec{F}}{\partial \dot{\alpha}_a} \frac{\partial \dot{\alpha}_a}{\partial \dot{\mathbf{x}}_3} \left( \frac{\partial \dot{\mathbf{x}}_3}{\partial \alpha_i} \right) + \frac{\partial \vec{F}}{\partial \dot{\beta}} \frac{\partial \dot{\beta}}{\partial \dot{\mathbf{x}}_2} \left( \frac{\partial \dot{\mathbf{x}}_2}{\partial \alpha_i} \right) \right] + \frac{\partial \vec{F}}{\partial \alpha_i} \\
 &= G'(t) \left( \frac{\partial \vec{x}}{\partial \alpha_i} \right) + \left[ \frac{\partial \vec{F}}{\partial \dot{\alpha}_a} \frac{\partial \dot{\alpha}_a}{\partial \dot{\mathbf{x}}_3} \left( \frac{\partial \dot{\mathbf{x}}_3}{\partial \alpha_i} \right) + \frac{\partial \vec{F}}{\partial \dot{\beta}} \frac{\partial \dot{\beta}}{\partial \dot{\mathbf{x}}_2} \left( \frac{\partial \dot{\mathbf{x}}_2}{\partial \alpha_i} \right) \right] + \frac{\partial \vec{F}}{\partial \alpha_i} \tag{C1}
 \end{aligned}$$

where

$$G'(t) = \left[ g'_{jk}(t) \right] \quad (j, k = 1, 2, \dots, 8)$$

The functions  $F_2$  and  $F_3$  do not contain  $\dot{\alpha}_a$  or  $\dot{\beta}$ . Thus,

$$\begin{aligned}
 \frac{d}{dt} \left( \frac{\partial \vec{x}}{\partial \alpha_i} \right) &= \left[ G'(t) \left( \frac{\partial \vec{x}}{\partial \alpha_i} \right) + \frac{\partial \vec{F}}{\partial \dot{\alpha}_a} \frac{\partial \dot{\alpha}_a}{\partial \dot{\mathbf{x}}_3} \sum_{k=1}^8 g'_{3k} \left( \frac{\partial \mathbf{x}_k}{\partial \alpha_i} \right) + \frac{\partial \vec{F}}{\partial \dot{\beta}} \frac{\partial \dot{\beta}}{\partial \dot{\mathbf{x}}_2} \sum_{k=1}^8 g'_{2k} \left( \frac{\partial \mathbf{x}_k}{\partial \alpha_i} \right) \right] \\
 &\quad + \left( \frac{\partial \vec{F}}{\partial \alpha_i} + \frac{\partial \vec{F}}{\partial \dot{\alpha}_a} \frac{\partial \dot{\alpha}_a}{\partial \dot{\mathbf{x}}_3} \frac{\partial F_3}{\partial \alpha_i} + \frac{\partial \vec{F}}{\partial \dot{\beta}} \frac{\partial \dot{\beta}}{\partial \dot{\mathbf{x}}_2} \frac{\partial F_2}{\partial \alpha_i} \right) \\
 &= G(t) \left( \frac{\partial \vec{x}}{\partial \alpha_i} \right) + \tilde{F}(\alpha_i) \quad (i = 1, 2, \dots, 40) \tag{C2}
 \end{aligned}$$

## APPENDIX C - Continued

where

$$\frac{\partial \tilde{\mathbf{x}}}{\partial \alpha_i} = \left[ \frac{\partial u}{\partial \alpha_i}, \frac{\partial v}{\partial \alpha_i}, \frac{\partial w}{\partial \alpha_i}, \frac{\partial p}{\partial \alpha_i}, \frac{\partial q}{\partial \alpha_i}, \frac{\partial r}{\partial \alpha_i}, \frac{\partial \theta}{\partial \alpha_i}, \frac{\partial \phi}{\partial \alpha_i} \right]^T$$

$$G(t) = \left[ g_{jk}(t) \right] \quad (j, k = 1, 2, \dots, 8)$$

$$\tilde{\mathbf{F}}(\alpha_i) = \left[ \tilde{F}_1(\alpha_i), \tilde{F}_2(\alpha_i), \dots, \tilde{F}_8(\alpha_i) \right]^T$$

(1) Sensitivity equations derived from  $\dot{u}$  equation:

$$\frac{d}{dt} \left( \frac{\partial u}{\partial \alpha_i} \right) = \sum_{k=1}^8 g_{1k} \left( \frac{\partial x_k}{\partial \alpha_i} \right) + \frac{\partial F_1}{\partial \alpha_i} \quad (C3)$$

where

$$g_{11} \approx a_1 u (2C_{X1} + C_{X2}) - a_1 C_{X_{\alpha_a}} w$$

$$g_{12} = r + a_1 v (2C_{X1} + C_{X2})$$

$$g_{13} \approx -q + a_1 w (2C_{X1} + C_{X2}) + a_1 C_{X_{\alpha_a}} u$$

$$g_{14} = 0$$

$$g_{15} = -w + a_2 V C_{X_q}$$

$$g_{16} = v$$

$$g_{17} = -g \cos \theta$$

$$g_{18} = 0$$

and

$$\frac{\partial F_1}{\partial \alpha_2} = a_1 V^2$$

$$\frac{\partial F_1}{\partial \alpha_3} = a_1 V^2 (\alpha_a - \alpha_{a,t})$$

$$\frac{\partial F_1}{\partial \alpha_4} = a_2 V q$$

(2) Sensitivity equations derived from  $\dot{v}$  equation:

$$\frac{d}{dt} \left( \frac{\partial v}{\partial \alpha_i} \right) = \sum_{k=1}^8 g_{2k} \left( \frac{\partial x_k}{\partial \alpha_i} \right) + \frac{\partial F_2}{\partial \alpha_i} \quad (C4)$$

where

$$g_{21} \approx \frac{-r + a_1 u (2C_{Y1} + C_{Y2} - C_{Y\beta}^\beta)}{1 - a_3 C_{Y\dot{\beta}}}$$

$$g_{22} \approx \frac{a_1 v (2C_{Y1} + C_{Y2} - C_{Y\beta}^\beta) + a_1 V C_{Y\beta}}{1 - a_3 C_{Y\dot{\beta}}}$$

$$g_{23} \approx \frac{p + a_1 w (2C_{Y1} + C_{Y2} - C_{Y\beta}^\beta)}{1 - a_3 C_{Y\dot{\beta}}}$$

$$g_{24} = \frac{w + a_3 V C_{Yp}}{1 - a_3 C_{Y\dot{\beta}}}$$

$$g_{25} = 0$$

$$g_{26} = \frac{-u + a_3 V C_{Yr}}{1 - a_3 C_{Y\dot{\beta}}}$$

$$g_{27} = \frac{-g \sin \theta \sin \phi}{1 - a_3 C_{Y\dot{\beta}}}$$

$$g_{28} = \frac{g \cos \theta \cos \phi}{1 - a_3 C_{Y\dot{\beta}}}$$

and

$$\frac{\partial F_2}{\partial \alpha_{19}} = \frac{a_1 V^2}{1 - a_3 C_{Y\dot{\beta}}}$$

$$\frac{\partial F_2}{\partial \alpha_{20}} = \frac{a_1 V^2 (\beta - \beta_t)}{1 - a_3 C_{Y\dot{\beta}}}$$

$$\frac{\partial F_2}{\partial \alpha_{21}} = \frac{a_3 \dot{v}}{1 - a_3 C_{Y\dot{\beta}}}$$

$$\frac{\partial F_2}{\partial \alpha_{22}} = \frac{a_3 V_p}{1 - a_3 C_{Y\dot{\beta}}}$$

$$\frac{\partial F_2}{\partial \alpha_{23}} = \frac{a_3 V_r}{1 - a_3 C_{Y\dot{\beta}}}$$

$$\frac{\partial F_2}{\partial \alpha_{24}} = \frac{a_1 V^2 (\delta_r - \delta_{r,t})}{1 - a_3 C_{Y\dot{\beta}}}$$

(3) Sensitivity equations derived from  $\dot{w}$  equation:

$$\frac{d}{dt} \left( \frac{\partial w}{\partial \alpha_i} \right) = \sum_{k=1}^8 g_{3k} \left( \frac{\partial x_k}{\partial \alpha_i} \right) + \frac{\partial F_3}{\partial \alpha_i} \quad (C5)$$

where

$$g_{31} \approx q + a_1 u (2C_{Z1} + C_{Z2}) - a_1 C_{Z\alpha_a} w$$

$$g_{32} = -p + a_1 v (2C_{Z1} + C_{Z2})$$

# APPENDIX C – Continued

$$g_{33} \approx a_1 w (2C_{Z1} + C_{Z2}) + a_1 C_{Z\alpha_a} u$$

$$g_{34} = -v$$

$$g_{35} = u + a_2 V C_{Zq}$$

$$g_{36} = 0$$

$$g_{37} = -g \sin \theta \cos \phi$$

$$g_{38} = -g \cos \theta \sin \phi$$

and

$$\frac{\partial F_3}{\partial \alpha_8} = a_1 V^2$$

$$\frac{\partial F_3}{\partial \alpha_9} = a_1 V^2 (\alpha_a - \alpha_{a,t})$$

$$\frac{\partial F_3}{\partial \alpha_{10}} = a_2 V q$$

$$\frac{\partial F_3}{\partial \alpha_{11}} = a_1 V^2 (\delta_e - \delta_{e,t})$$

(4) Sensitivity equations derived from  $\dot{p}$  equation:

$$\begin{aligned} \frac{d}{dt} \left( \frac{\partial p}{\partial \alpha_i} \right) &= a_6 \left[ \sum_{k=1}^8 \left( g'_{4k} + \frac{\partial F'_4}{\partial \beta} \frac{\partial \beta}{\partial v} g_{2k} \right) \left( \frac{\partial x_k}{\partial \alpha_i} \right) + \left( \frac{\partial F'_4}{\partial \alpha_i} + \frac{\partial F'_4}{\partial \beta} \frac{\partial \beta}{\partial v} \frac{\partial F_2}{\partial \alpha_i} \right) \right] + b_1 \left[ \sum_{k=1}^8 \left( g'_{6k} + \frac{\partial F'_6}{\partial \beta} \frac{\partial \beta}{\partial v} g_{2k} \right) \left( \frac{\partial x_k}{\partial \alpha_i} \right) + \left( \frac{\partial F'_6}{\partial \alpha_i} + \frac{\partial F'_6}{\partial \beta} \frac{\partial \beta}{\partial v} \frac{\partial F_2}{\partial \alpha_i} \right) \right] \\ &= \sum_{k=1}^8 \left( g'_{4k} + a_6 \frac{\partial F'_4}{\partial \beta} \frac{\partial \beta}{\partial v} g_{2k} + b_1 \frac{\partial F'_6}{\partial \beta} \frac{\partial \beta}{\partial v} g_{2k} \right) \left( \frac{\partial x_k}{\partial \alpha_i} \right) + a_6 \tilde{F}'_4(\alpha_i) + b_1 \tilde{F}'_6(\alpha_i) \\ &= \sum_{k=1}^8 g_{4k} \left( \frac{\partial x_k}{\partial \alpha_i} \right) + \tilde{F}_4(\alpha_i) \end{aligned} \tag{C6}$$

# APPENDIX C - Continued

where

$$g''_{41} \approx a_4 u \left( 2C_{l1} + C_{l2} + 2C_{l3} \frac{V_S}{V} - C_{l\beta} \beta - C_{l\dot{\beta}} \frac{\dot{\beta} b}{2V} \right)$$

$$g''_{42} \approx a_4 v \left( 2C_{l1} + C_{l2} + 2C_{l3} \frac{V_S}{V} - C_{l\beta} \beta - C_{l\dot{\beta}} \frac{\dot{\beta} b}{2V} \right) + a_4 v C_{l\beta}$$

$$g''_{43} \approx a_4 w \left( 2C_{l1} + C_{l2} + 2C_{l3} \frac{V_S}{V} - C_{l\beta} \beta - C_{l\dot{\beta}} \frac{\dot{\beta} b}{2V} \right)$$

$$g''_{44} = I_{XZ} q + a_5 v C_{lp}$$

$$g''_{45} = b_2 r + I_{XZ} p$$

$$g''_{46} = b_2 q + a_5 v C_{lr}$$

$$g''_{47} = g''_{48} = 0$$

and

$$g''_{61} \approx a_4 u \left( 2C_{n1} + C_{n2} - 2C_{n3} \frac{V_S}{V} - C_{n\beta} \beta - C_{n\dot{\beta}} \frac{\dot{\beta} b}{2V} \right)$$

$$g''_{62} \approx a_4 v \left( 2C_{n1} + C_{n2} - 2C_{n3} \frac{V_S}{V} - C_{n\beta} \beta - C_{n\dot{\beta}} \frac{\dot{\beta} b}{2V} \right) + a_4 v C_{n\beta}$$

$$g''_{63} \approx a_4 w \left( 2C_{n1} + C_{n2} - 2C_{n3} \frac{V_S}{V} - C_{n\beta} \beta - C_{n\dot{\beta}} \frac{\dot{\beta} b}{2V} \right)$$

$$g''_{64} = b_3 q + a_5 v C_{np}$$

$$g''_{65} = b_3 p - I_{XZ} r$$

# APPENDIX C - Continued

$$g''_{66} = -I_{XZ}q + a_5 V C_{n_r}$$

$$g''_{67} = g''_{68} = 0$$

and

$$\frac{\partial F'_4}{\partial \alpha_{26}} = \frac{\partial F'_6}{\partial \alpha_{34}} = a_4 V^2$$

$$\frac{\partial F'_4}{\partial \alpha_{27}} = \frac{\partial F'_6}{\partial \alpha_{35}} = a_4 V^2 (\beta - \beta_t)$$

$$\frac{\partial F'_4}{\partial \alpha_{28}} = \frac{\partial F'_6}{\partial \alpha_{36}} = a_5 V \dot{\beta}$$

$$\frac{\partial F'_4}{\partial \alpha_{29}} = \frac{\partial F'_6}{\partial \alpha_{37}} = a_5 V p$$

$$\frac{\partial F'_4}{\partial \alpha_{30}} = \frac{\partial F'_6}{\partial \alpha_{38}} = a_5 V r$$

$$\frac{\partial F'_4}{\partial \alpha_{31}} = \frac{\partial F'_6}{\partial \alpha_{39}} = a_4 V^2 (\delta_r - \delta_{r,t})$$

$$\frac{\partial F'_4}{\partial \alpha_{32}} = -\frac{\partial F'_6}{\partial \alpha_{40}} = a_4 V S^2 \cos i_w (\delta_a - \delta_{a,t})$$

$$\frac{\partial F'_4}{\partial \alpha_{40}} = \frac{\partial F'_6}{\partial \alpha_{32}} = -a_4 V S^2 \sin i_w (\delta_a - \delta_{a,t})$$

$$\frac{\partial F'_4}{\partial \dot{\beta}} \frac{\partial \dot{\beta}}{\partial \dot{v}} = a_5 C_{l\dot{\beta}}$$

$$\frac{\partial F'_6}{\partial \dot{\beta}} \frac{\partial \dot{\beta}}{\partial \dot{v}} = a_5 C_{n\dot{\beta}}$$

# APPENDIX C -- Continued

(5) Sensitivity equations derived from  $\dot{q}$  equation:

$$\begin{aligned} \frac{d}{dt} \left( \frac{\partial q}{\partial \alpha_i} \right) &= \sum_{k=1}^8 \left( g'_{5k} + \frac{\partial F_5}{\partial \dot{\alpha}_a} \frac{\partial \dot{\alpha}_a}{\partial \dot{w}} g_{3k} \right) \left( \frac{\partial x_k}{\partial \alpha_i} \right) + \left( \frac{\partial F_5}{\partial \alpha_i} + \frac{\partial F_5}{\partial \dot{\alpha}_a} \frac{\partial \dot{\alpha}_a}{\partial \dot{w}} \frac{\partial F_3}{\partial \alpha_i} \right) \\ &= \sum_{k=1}^8 g_{5k} \left( \frac{\partial x_k}{\partial \alpha_i} \right) + \tilde{F}_5(\alpha_i) \end{aligned} \quad (C7)$$

where

$$g'_{51} \approx a_8 u (2C_{m1} + C_{m2}) - a_8 C_{m\alpha_a} w - a_9 C_{m\dot{\alpha}_a} \dot{\alpha}_a$$

$$g'_{52} = a_8 v (2C_{m1} + C_{m2})$$

$$g'_{53} \approx a_8 w (2C_{m1} + C_{m2}) + a_8 C_{m\alpha_a} u$$

$$g'_{54} = a_7 r - 2b_4 p$$

$$g'_{55} = a_9 V C_{mq}$$

$$g'_{56} = a_7 p + 2b_4 r$$

$$g'_{57} = g'_{58} = 0$$

and

$$\frac{\partial F_5}{\partial \alpha_{13}} = a_8 V^2$$

$$\frac{\partial F_5}{\partial \alpha_{14}} = a_8 V^2 (\alpha_a - \alpha_{a,t})$$

## APPENDIX C – Continued

$$\frac{\partial F_5}{\partial \alpha_{15}} = a_9 V \dot{\alpha}_a$$

$$\frac{\partial F_5}{\partial \alpha_{16}} = a_9 V q$$

$$\frac{\partial F_5}{\partial \alpha_{17}} = a_8 V^2 (\delta_e - \delta_{e,t})$$

$$\frac{\partial F_5}{\partial \dot{\alpha}_a} \frac{\partial \dot{\alpha}_a}{\partial \dot{w}} \approx a_9 C_m \dot{\alpha}_a$$

(6) Sensitivity equations derived from  $\dot{r}$  equation:

$$\begin{aligned} \frac{d}{dt} \left( \frac{\partial r}{\partial \alpha_i} \right) &= b_1 \left[ \sum_{k=1}^8 \left( g''_{4k} + \frac{\partial F'_4}{\partial \dot{\beta}} \frac{\partial \dot{\beta}}{\partial \dot{v}} g_{2k} \right) \left( \frac{\partial x_k}{\partial \alpha_i} \right) + \left( \frac{\partial F'_4}{\partial \alpha_i} + \frac{\partial F'_4}{\partial \dot{\beta}} \frac{\partial \dot{\beta}}{\partial \dot{v}} \frac{\partial F_2}{\partial \alpha_i} \right) \right] \\ &\quad + b_5 \left[ \sum_{k=1}^8 \left( g''_{6k} + \frac{\partial F'_6}{\partial \dot{\beta}} \frac{\partial \dot{\beta}}{\partial \dot{v}} g_{2k} \right) \left( \frac{\partial x_k}{\partial \alpha_i} \right) + \left( \frac{\partial F'_6}{\partial \alpha_i} + \frac{\partial F'_6}{\partial \dot{\beta}} \frac{\partial \dot{\beta}}{\partial \dot{v}} \frac{\partial F_2}{\partial \alpha_i} \right) \right] \\ &= \sum_{k=1}^8 \left( g'_{6k} + b_1 \frac{\partial F'_4}{\partial \dot{\beta}} \frac{\partial \dot{\beta}}{\partial \dot{v}} g_{2k} + b_5 \frac{\partial F'_6}{\partial \dot{\beta}} \frac{\partial \dot{\beta}}{\partial \dot{v}} g_{2k} \right) \left( \frac{\partial x_k}{\partial \alpha_i} \right) + b_1 \tilde{F}'_4(\alpha_i) + b_5 \tilde{F}'_6(\alpha_i) \\ &= \sum_{k=1}^8 g_{6k} \left( \frac{\partial x_k}{\partial \alpha_i} \right) + \tilde{F}_6(\alpha_i) \end{aligned} \tag{C8}$$

where all the terms have been defined in the derivation of the sensitivity equations for  $\dot{p}$  equation.

## APPENDIX C - Continued

(7) Sensitivity equations derived from  $\dot{\theta}$  equation:

$$\frac{d}{dt} \left( \frac{\partial \theta}{\partial \alpha_i} \right) = \sum_{k=1}^8 g_{7k} \left( \frac{\partial x_k}{\partial \alpha_i} \right) \quad (C9)$$

where

$$g_{71} = g_{72} = g_{73} = g_{74} = 0$$

$$g_{75} = \cos \phi$$

$$g_{76} = -\sin \phi$$

$$g_{77} = 0$$

$$g_{78} = -\dot{\psi} \cos \theta$$

(8) Sensitivity equations derived from  $\dot{\phi}$  equation:

$$\frac{d}{dt} \left( \frac{\partial \phi}{\partial \alpha_i} \right) = \sum_{k=1}^8 g_{8k} \left( \frac{\partial x_k}{\partial \alpha_i} \right) \quad (C10)$$

where

$$g_{81} = g_{82} = g_{83} = 0$$

$$g_{84} = 1$$

$$g_{85} = \sin \phi \tan \theta$$

$$g_{86} = \cos \phi \tan \theta$$

## APPENDIX C – Concluded

$$g_{87} = \frac{\dot{\psi}}{\cos \theta}$$

$$g_{88} = \dot{\theta} \tan \theta$$

The accelerometer sensitivity coefficients were derived in terms of the sensitivity equations and coefficients for the equations of motion, and need only to be evaluated and not integrated.

(1) Sensitivity equations derived from  $a_{X,I}$  equation:

$$\begin{aligned} \frac{\partial a_{X,I}}{\partial \alpha_i} = \frac{1}{g} & \left[ -r \left( \frac{\partial v}{\partial \alpha_i} \right) + q \left( \frac{\partial w}{\partial \alpha_i} \right) + (y_X q + z_X r) \left( \frac{\partial p}{\partial \alpha_i} \right) + (-2x_X q + y_X p + w) \left( \frac{\partial q}{\partial \alpha_i} \right) \right. \\ & \left. + (-2x_X r + z_X p - v) \left( \frac{\partial r}{\partial \alpha_i} \right) + g \cos \theta \left( \frac{\partial \theta}{\partial \alpha_i} \right) + \left( \frac{\partial \dot{u}}{\partial \alpha_i} \right) + z_X \left( \frac{\partial \dot{q}}{\partial \alpha_i} \right) - y_X \left( \frac{\partial \dot{r}}{\partial \alpha_i} \right) \right] \end{aligned} \quad (C11)$$

(2) Sensitivity equations derived from  $a_{Y,I}$  equation:

$$\begin{aligned} \frac{\partial a_{Y,I}}{\partial \alpha_i} = \frac{1}{g} & \left[ r \left( \frac{\partial u}{\partial \alpha_i} \right) - p \left( \frac{\partial w}{\partial \alpha_i} \right) + (-w + x_Y q - 2y_Y p) \left( \frac{\partial p}{\partial \alpha_i} \right) + (x_Y p + z_Y r) \left( \frac{\partial q}{\partial \alpha_i} \right) + (u - 2y_Y r + z_Y q) \left( \frac{\partial r}{\partial \alpha_i} \right) \right. \\ & \left. + g \sin \theta \sin \phi \left( \frac{\partial \theta}{\partial \alpha_i} \right) - g \cos \theta \cos \phi \left( \frac{\partial \phi}{\partial \alpha_i} \right) + \left( \frac{\partial \dot{v}}{\partial \alpha_i} \right) - z_Y \left( \frac{\partial \dot{p}}{\partial \alpha_i} \right) + x_Y \left( \frac{\partial \dot{r}}{\partial \alpha_i} \right) \right] \end{aligned} \quad (C12)$$

(3) Sensitivity equations derived from  $a_{Z,I}$  equation:

$$\begin{aligned} \frac{\partial a_{Z,I}}{\partial \alpha_i} = \frac{1}{g} & \left[ -q \left( \frac{\partial u}{\partial \alpha_i} \right) + p \left( \frac{\partial v}{\partial \alpha_i} \right) + (v + x_Z r - 2z_Z p) \left( \frac{\partial p}{\partial \alpha_i} \right) + (-u + y_Z r - 2z_Z q) \left( \frac{\partial q}{\partial \alpha_i} \right) + (x_Z p + y_Z q) \left( \frac{\partial r}{\partial \alpha_i} \right) \right. \\ & \left. + g \sin \theta \cos \phi \left( \frac{\partial \theta}{\partial \alpha_i} \right) + g \cos \theta \sin \phi \left( \frac{\partial \phi}{\partial \alpha_i} \right) + \left( \frac{\partial \dot{w}}{\partial \alpha_i} \right) + y_Z \left( \frac{\partial \dot{p}}{\partial \alpha_i} \right) - x_Z \left( \frac{\partial \dot{q}}{\partial \alpha_i} \right) \right] \end{aligned} \quad (C13)$$

## APPENDIX D

### VARIABLE DIMENSIONING

The flight test runs do not necessitate the use of all the equation variables ( $\bar{x}$ ), variables in the performance index function ( $\bar{y}$ ), and parameters ( $\bar{\alpha}$ ) for specific cases. These cases involve only a specific part of the program, as with an excitation of only the longitudinal motion of the aircraft. Variable dimensioning of the estimation procedure furnishes the analyst with the means of altering the program to meet the specific needs of each flight test run; that is, the mathematical model of the aircraft dynamic response, the variables to be compared with flight test data, and the parameters to be estimated.

Variable dimensioning of the estimation procedure is accomplished by using the three input arrays INTX(8), INTY(11), and INTEG<sub>40</sub> (INTEG(I), I = 1, 2, . . . , 40); the use of these arrays dimension  $\bar{x}$ ,  $\bar{y}$ , and  $\bar{\alpha}$ , respectively, in the program. The elements of each array are entered as integers 1 or 0 to indicate whether the variables or parameters are active or inactive, respectively.

The input array INTX specifies the activeness for each equation variable in the equations of motion and the sensitivity equations; inactive variables are treated as constants. From the input array INTX

$$\text{INTX} = (1, 0, 1, \dots, 1, 0)$$

$$k_1 \quad k_2, \dots, k_{IV}$$

$$IV = \sum_{K=1}^8 \text{INTX}(K)$$

where  $k_1, k_2, \dots, k_{IV}$  are element locations, INTV is generated,

$$\text{INTV} = (k_1, k_2, \dots, k_{IV}, 0, \dots, 0)$$

which is a sequence of integers denoting the active equation variables in  $\bar{x}$ .

The input array INTY specifies the activeness for each variable in  $\bar{y}$ ; inactive variables are ignored. From the input array INTY

# APPENDIX D – Continued

$$\text{INTY} = (1, 0, 1, \dots, 1, 0) \\ j_1 \quad j_2, \dots, j_{IA}$$

$$IA = \sum_{J=1}^{11} \text{INTY}(J)$$

INTA is generated,

$$\text{INTA} = (j_1, j_2, \dots, j_{IA}, 0, \dots, 0)$$

which is a sequence of integers denoting the active variables in  $\vec{y}$ . The integer IA1, where

$$IA1 = \sum_{J=1}^8 \text{INTY}(J)$$

denotes the number of active variables in  $\vec{x}$  that are active variables in  $\vec{y}$ .

The input array  $\text{INTEG}_{40}$  specifies the activeness of each parameter in the estimation procedure; inactive parameters are treated as constants. From the input array  $\text{INTEG}_{40}$

$$\text{INTEG}_{40} = (0, \dots, 0, 1, 0, 1, \dots, 1, 0, \dots, 0) \\ i_1 \quad i_2, \dots, i_{IP}$$

$$IP = \sum_{I=1}^{40} \text{INTEG}(I)$$

INTP is generated,

$$\text{INTP} = (i_1, i_2, \dots, i_{IP}, 0, \dots, 0)$$

which is a sequence of integers denoting the active parameters in  $\vec{\alpha}$ . The program is dimensioned for  $IP \leq 30$ .

The resulting arrays (INTV, INTA, INTP) and numbers (IV, IA, IA1, IP) are used in FORTRAN DO LOOP and matrix operations.

## APPENDIX D - Continued

The equations of motion are reduced to the form

$$\ddot{\vec{x}}_{eq} = \vec{F}_{eq}(\vec{x}, \vec{\alpha}, \vec{\delta}) = (\dot{x}_{k_1}, \dot{x}_{k_2}, \dots, \dot{x}_{k_{IV}})^T \quad (D1)$$

by multiplying each of the original equations of motion (eq. (1a)) by their respective element of INTX; that is, inactive equation variables have their derivatives set to zero.

The original sensitivity equations (eq. (6)) are reduced by using the arrays INTP and INTV as indices in the FORTRAN DO LOOP to the form

$$\frac{d}{dt} \left( \frac{\partial \vec{x}_{INTV(K')}}{\partial \alpha_{INTP(I)}} \right) = \sum_{K=1}^{IV} \frac{\partial \vec{F}_{INTV(K')}}{\partial \vec{x}_{INTV(K)}} \left( \frac{\partial \vec{x}_{INTV(K)}}{\partial \alpha_{INTP(I)}} \right) + \frac{\partial \vec{F}_{INTV(K')}}{\partial \alpha_{INTP(I)}} \quad (K' = 1, 2, \dots, IV; I = 1, 2, \dots, IP) \quad (D2)$$

The accelerometer equations and sensitivity coefficients are handled in a similar manner to generate  $\vec{a}_J$  and  $\partial \vec{a}_J / \partial \alpha_{INTP(I)}$ , respectively.

The original parameter change equations (eq. (7)) reduce to

$$\Delta \vec{\alpha}_J = \left[ \sum_{i=1}^N A_J^T(t_i) R_J^{-1} A_J(t_i) \right]^{-1} \left[ \sum_{i=1}^N A_J^T(t_i) R_J^{-1} \vec{\eta}_J(t_i) \right] \quad (D3)$$

where

$$A_J(t_i) = \left( \frac{\partial \vec{y}_J^0}{\partial \alpha_{i_1}}, \frac{\partial \vec{y}_J^0}{\partial \alpha_{i_2}}, \dots, \frac{\partial \vec{y}_J^0}{\partial \alpha_{i_{IP}}} \right)$$

$$\vec{\eta}_J(t_i) = \vec{y}_J^M(t_i) - \vec{y}_J^0(t_i)$$

$$\vec{y}_J^M(t_i) = \begin{bmatrix} \vec{x}_J^M(t_i) \\ \vec{a}_J^M(t_i) \end{bmatrix}$$

$$\vec{y}_J^0 = \begin{bmatrix} \vec{x}_J^0(t_i) \\ \vec{a}_J^0(t_i) \end{bmatrix}$$

## APPENDIX D – Concluded

The vector  $\partial \bar{\mathbf{x}}_{\text{eq}} / \partial \alpha_{\text{INTP(I)}}$  is searched at each  $t_i$  for the sensitivity coefficients associated with the active algorithm variables by using the array INTA. The selected sensitivity coefficients are then packed into the vector  $\partial \bar{\mathbf{x}}_J / \partial \alpha_{\text{INTP(I)}}$  in order to form  $\mathbf{A}_J(t)$ . If  $\text{IA1} = \text{IV}$ , no search is made, since this condition implies that  $\bar{\mathbf{x}}_{\text{eq}} = \bar{\mathbf{x}}_J$ . The INTA array also selects  $\bar{\boldsymbol{\eta}}_J(t_i)$  from the original vector  $\bar{\boldsymbol{\eta}}(t_i)$ .

The covariance matrix for the parameters becomes

$$\left[ \sum_{i=1}^N \mathbf{A}_J^T(t_i) \mathbf{R}_J^{-1} \mathbf{A}_J(t_i) \right]^{-1} = \begin{bmatrix} \sigma_{\alpha_{i1}}^2 & \rho_{\alpha_{i1}\alpha_{i2}} \sigma_{\alpha_{i1}} \sigma_{\alpha_{i2}} & \cdots & \rho_{\alpha_{i1}\alpha_{i\text{IP}}} \sigma_{\alpha_{i1}} \sigma_{\alpha_{i\text{IP}}} \\ \rho_{\alpha_{i2}\alpha_{i1}} \sigma_{\alpha_{i2}} \sigma_{\alpha_{i1}} & \sigma_{\alpha_{i2}}^2 & \cdots & \rho_{\alpha_{i2}\alpha_{i\text{IP}}} \sigma_{\alpha_{i2}} \sigma_{\alpha_{i\text{IP}}} \\ \vdots & \vdots & \ddots & \vdots \\ \rho_{\alpha_{i\text{IP}}\alpha_{i1}} \sigma_{\alpha_{i\text{IP}}} \sigma_{\alpha_{i1}} & \rho_{\alpha_{i\text{IP}}\alpha_{i2}} \sigma_{\alpha_{i\text{IP}}} \sigma_{\alpha_{i2}} & \cdots & \sigma_{\alpha_{i\text{IP}}}^2 \end{bmatrix} \quad (\text{D4})$$

The covariance matrix for the measurement noise becomes

$$\mathbf{R}_J^0(N) \triangleq \text{Estimate of } \mathbf{R}_J = \frac{1}{N} \sum_{i=1}^N \bar{\boldsymbol{\eta}}_J(t_i) \bar{\boldsymbol{\eta}}_J^T(t_i) = \begin{bmatrix} \sigma_{\eta_{j1}}^2 & \sigma_{\eta_{j1}\eta_{j2}} & \cdots & \sigma_{\eta_{j1}\eta_{j\text{IA}}} \\ \sigma_{\eta_{j2}\eta_{j1}} & \sigma_{\eta_{j2}}^2 & \cdots & \sigma_{\eta_{j2}\eta_{j\text{IA}}} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{\eta_{j\text{IA}}\eta_{j1}} & \sigma_{\eta_{j\text{IA}}\eta_{j2}} & \cdots & \sigma_{\eta_{j\text{IA}}}^2 \end{bmatrix} \quad (\text{D5})$$

and the performance index to be minimized becomes

$$J_N(\tilde{\boldsymbol{\alpha}}_J^0) = |\mathbf{R}_J^0(N)| \quad (\text{D6})$$

## APPENDIX E

### CALCOMP PLOT OPTION

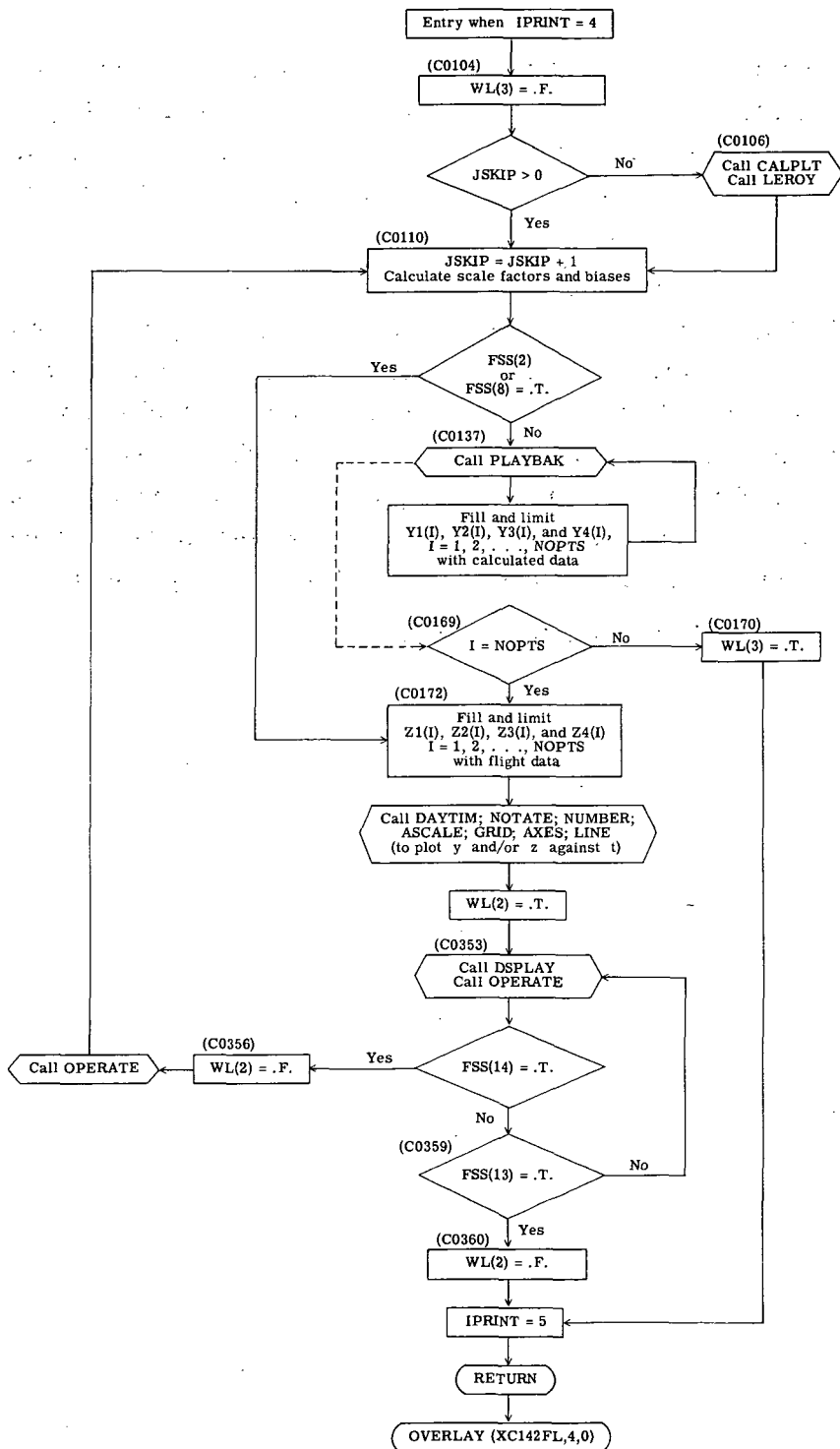
CalComp plots similar to the CRT displays can be obtained in overlay level (2,0). The main difference being that the (+) symbol is used to represent flight data points. Other differences are options to plot flight data only (FSS(2) true), and a variable (NPLLOT) to alter the density of flight data points to be plotted. Examples of CalComp plots are shown in figures 2 and 4.

The CalComp plot option is entered by setting IPRINT to 4 by means of the DDDU before exiting the CRT display loop. (Replotting of the CRT display just before entering the CalComp plot option causes erasure of the real-time disk file, and thereby prevents CalComp plots of calculated data.) After exiting the CRT loop, set FSS as shown in the CRT discussion of overlay level (4,0), and depress PRINT switch. When processing of the selected plot is completed, WL(2) will come on to signal the need for operator action. Additional plots can be obtained by setting the appropriate FSS before depressing FSS(14) and then releasing. Exiting the CalComp loop is accomplished by depressing FSS(13).

The flow chart of the CalComp plot option follows.

# APPENDIX E – Concluded

## CALCOMP PLOT OPTION



## REFERENCES

1. Grove, Randall, D.; Bowles, Roland L.; and Mayhew, Stanley C.: A Procedure for Estimating Stability and Control Parameters From Flight Test Data by Using Maximum Likelihood Methods Employing a Real-Time Digital System. NASA TN D-6735, 1972.
2. Steinmetz, George G.; Parrish, Russell V.; and Bowles, Roland L.: Longitudinal Stability and Control Derivatives of a Jet Fighter Airplane Extracted From Flight Test Data by Utilizing Maximum Likelihood Estimation. NASA TN D-6532, 1972.
3. Suit, William T.: Aerodynamic Parameters of the Navion Airplane Extracted From Flight Data. NASA TN D-6643, 1972.
4. Parrish, Russell V.; and Steinmetz, George G.: Lateral Stability and Control Derivatives of a Jet Fighter Airplane Extracted From Flight Test Data by Utilizing Maximum Likelihood Estimation. NASA TN D-6905, 1972.
5. Williams, James L.: Extraction of Longitudinal Aerodynamic Coefficients From Forward-Flight Conditions of a Tilt-Wing V/STOL Airplane. NASA TN D-7114, 1972.
6. Gainer, Thomas G.; and Hoffman, Sherwood: Summary of Transformation Equations and Equations of Motion Used in Free-Flight and Wind-Tunnel Data Reduction and Analysis. NASA SP-3070, 1972.

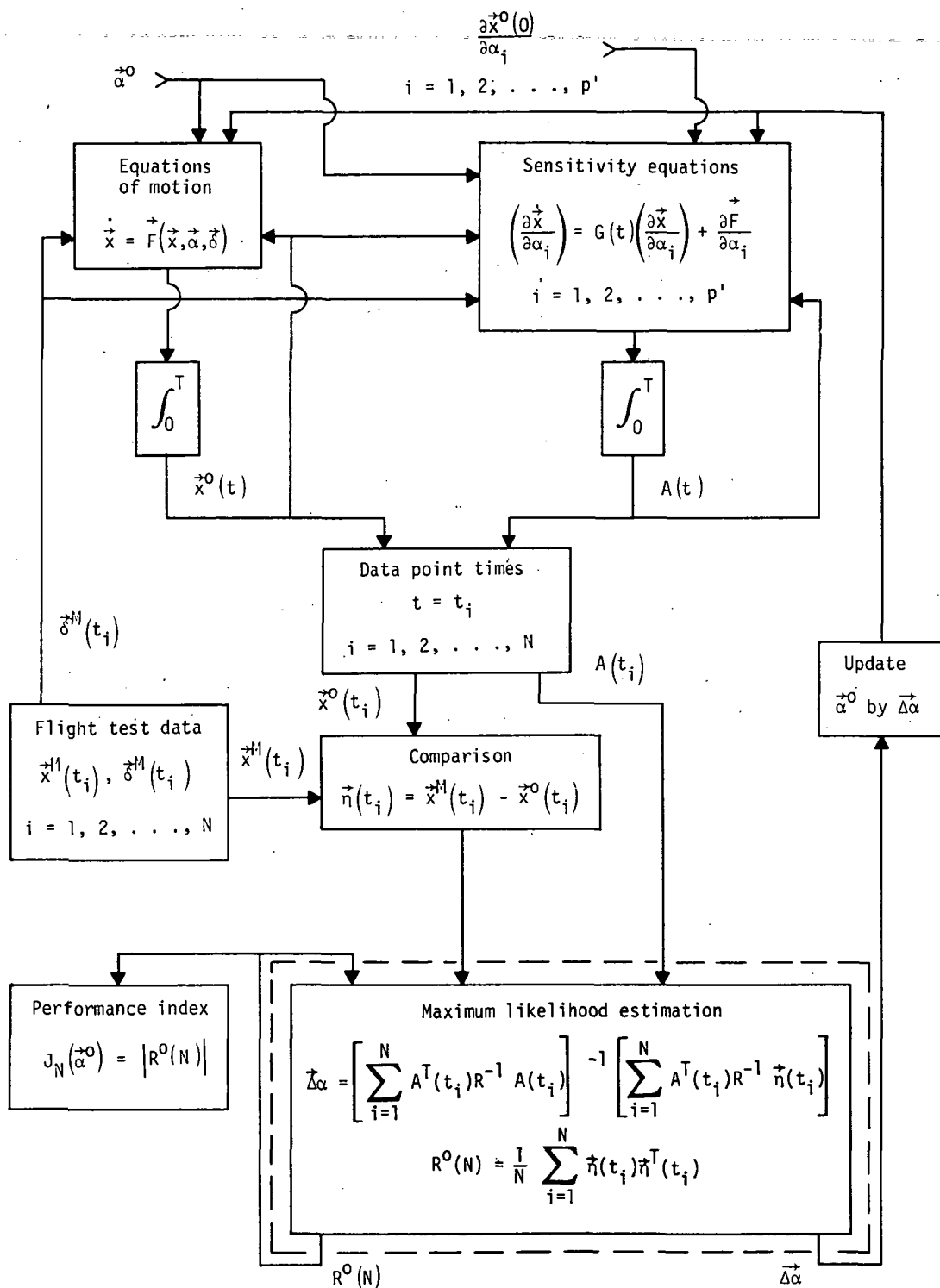
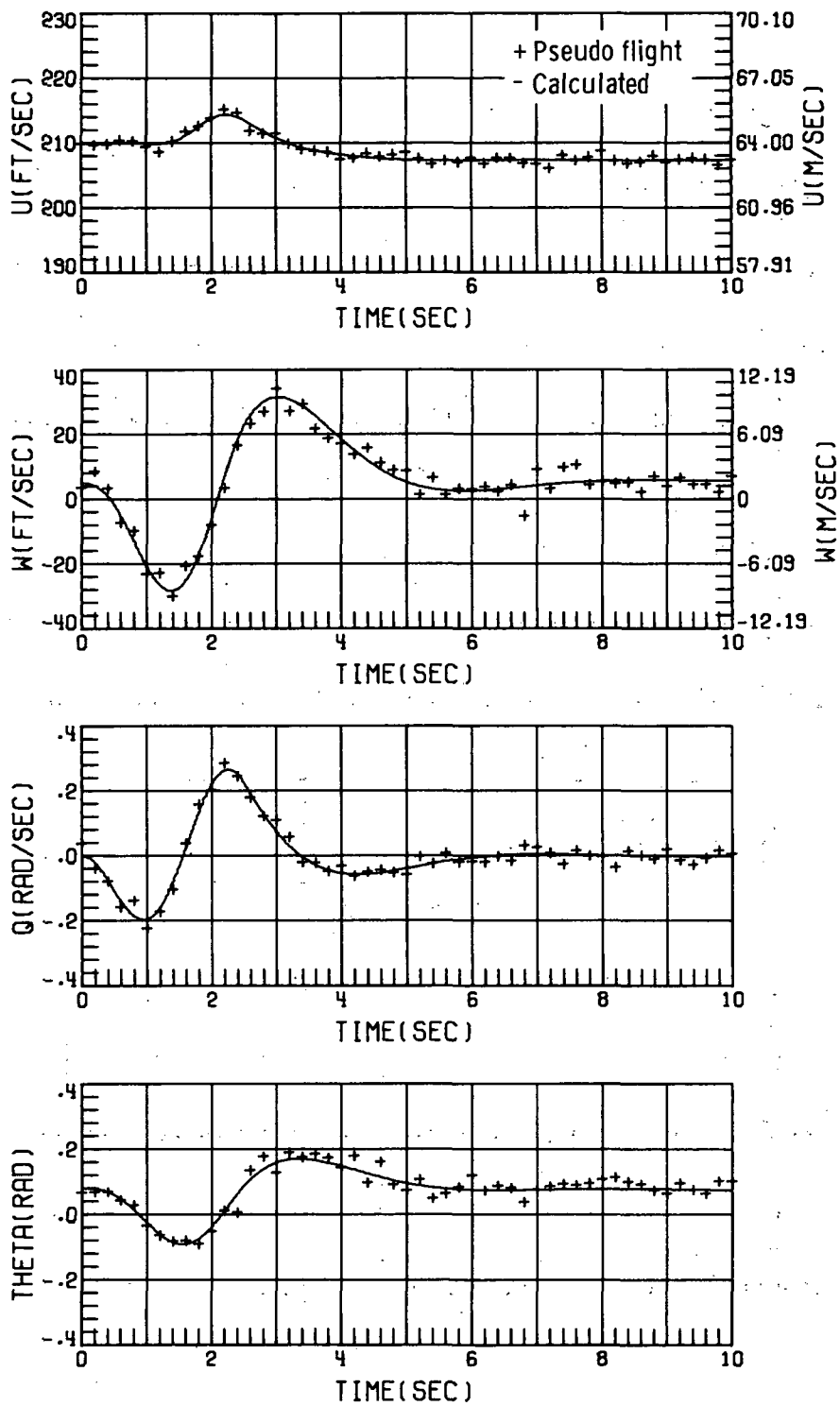
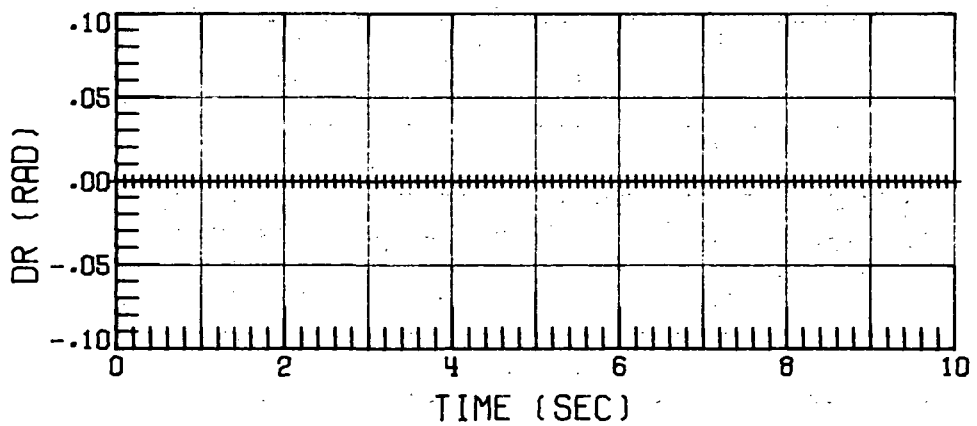
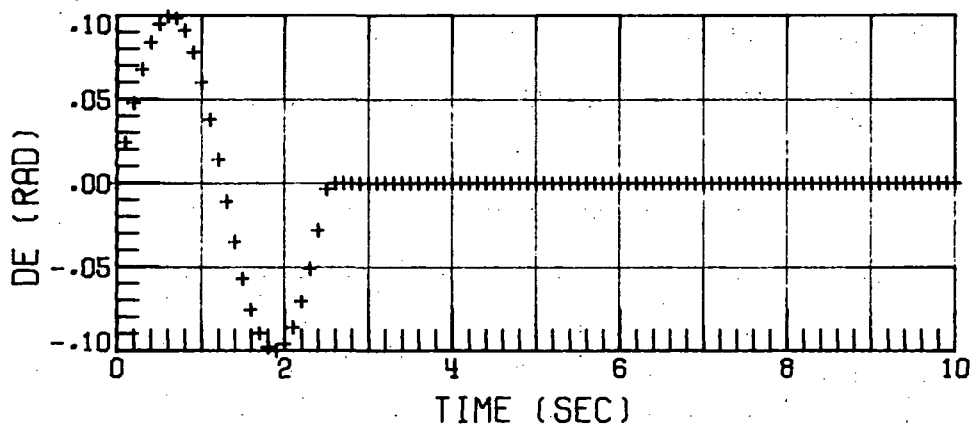
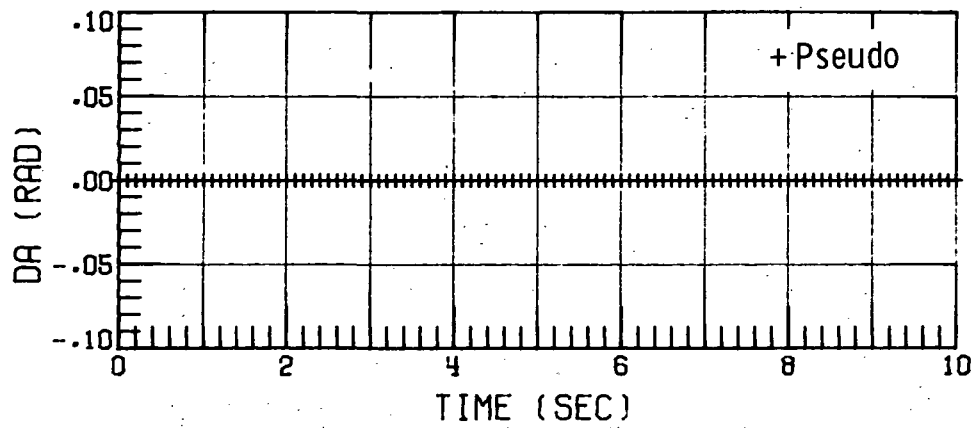


Figure 1.- Maximum likelihood parameter estimation procedure.



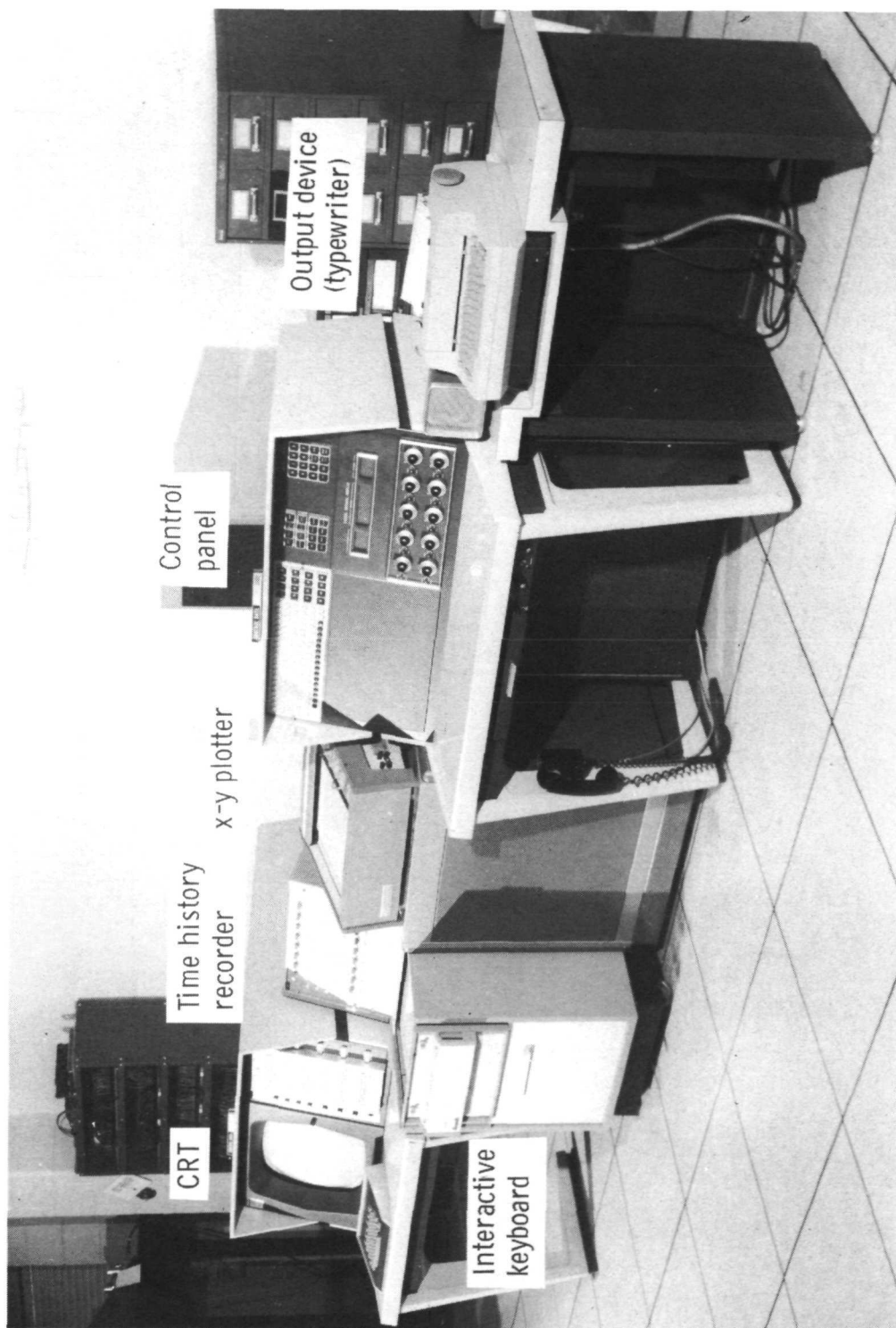
(a) Longitudinal motion.

Figure 2.- CalComp plot of pseudo flight and calculated (converged solution) longitudinal motion, and control inputs.



(b) Control inputs.

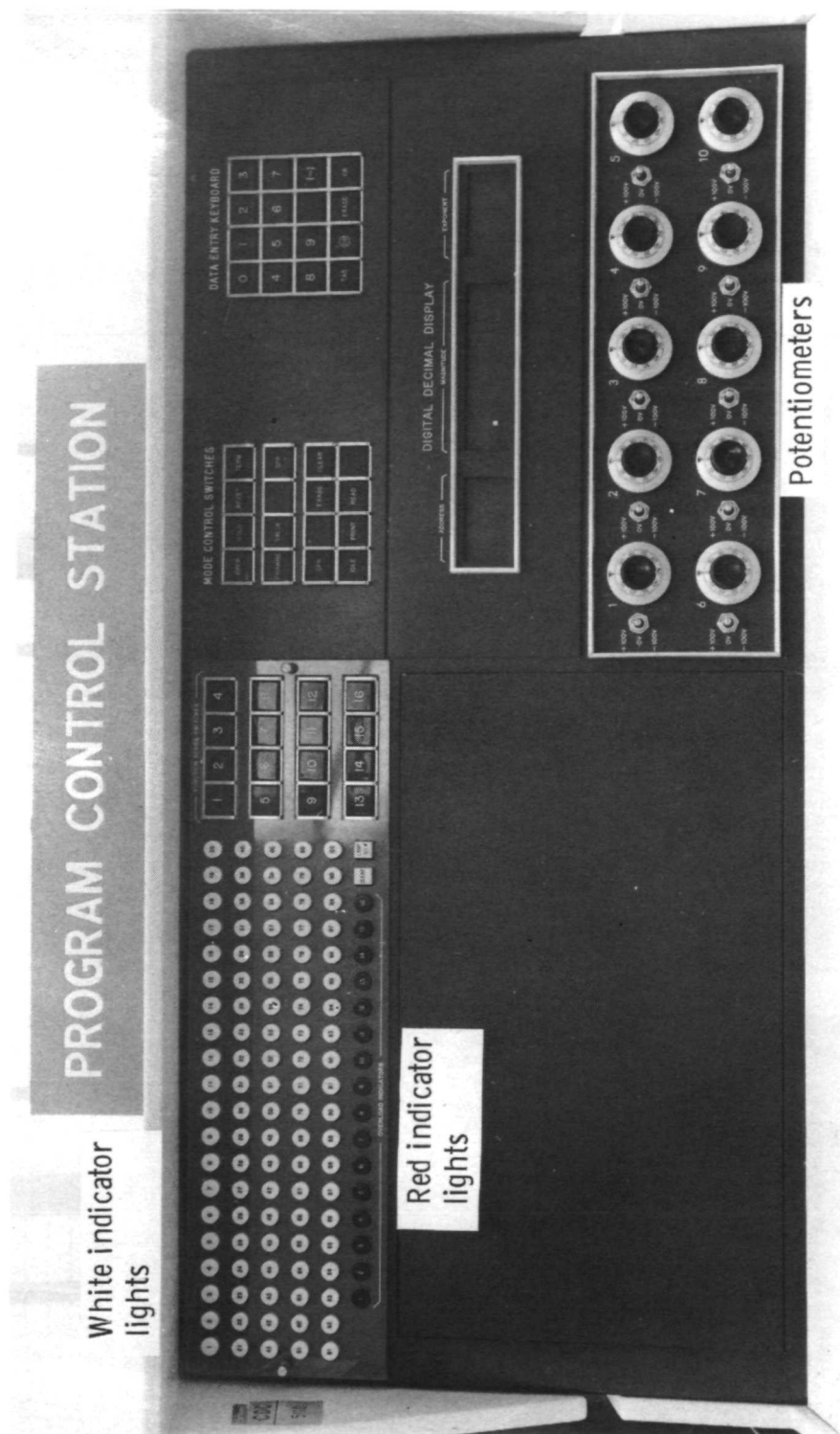
Figure 2.- Concluded.



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(a) Typical program control station.

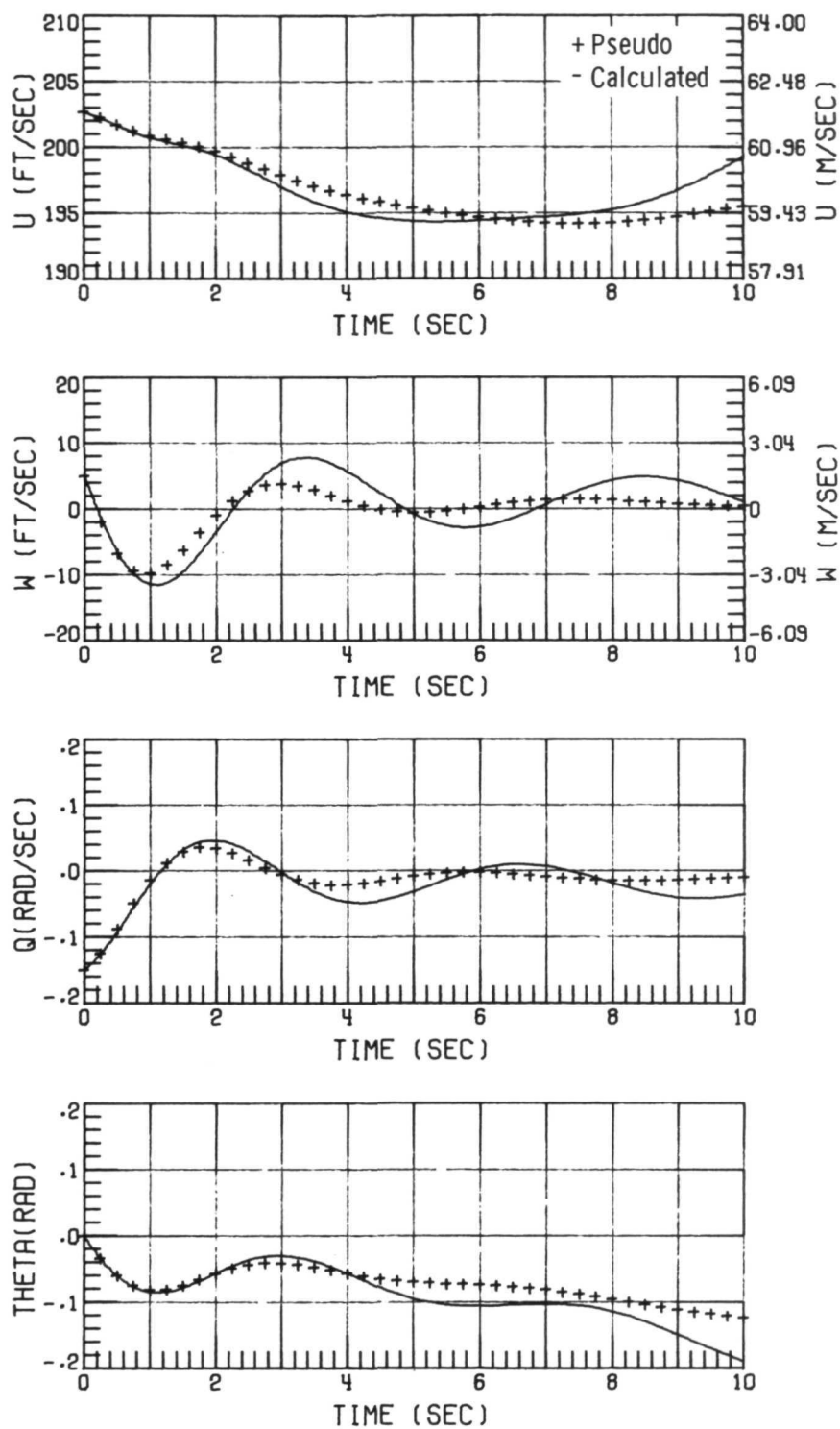
Figure 3.- Operational control features.



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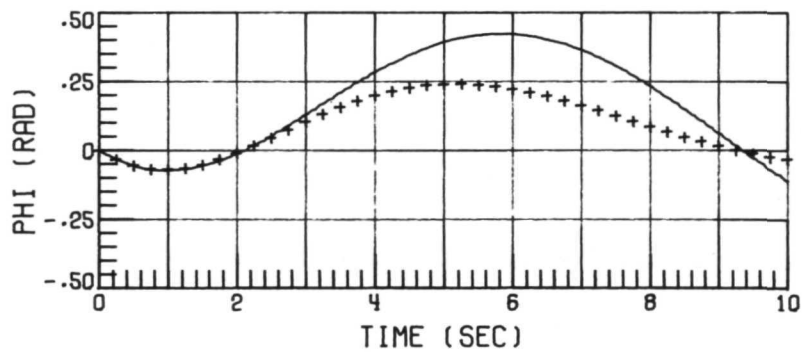
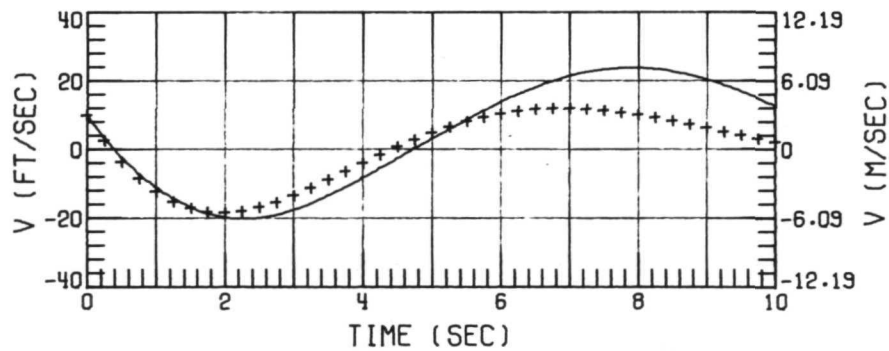
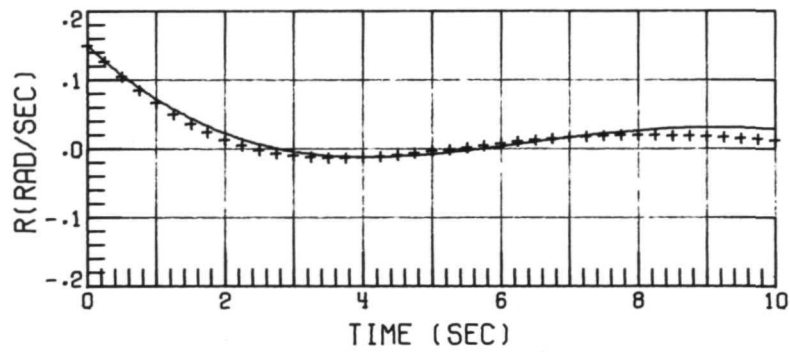
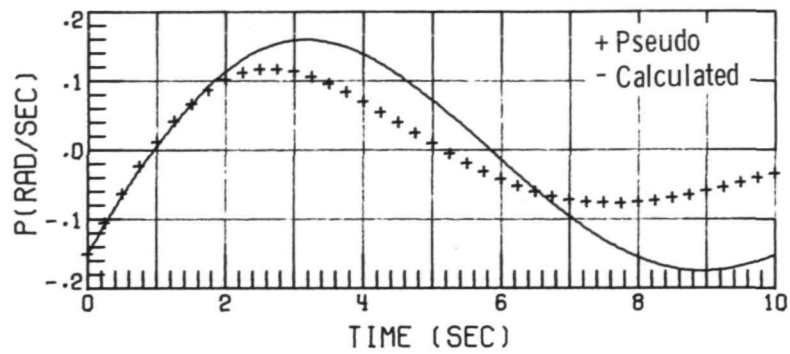
(b) Closeup of control panel on the program control console.

Figure 3.- Concluded.



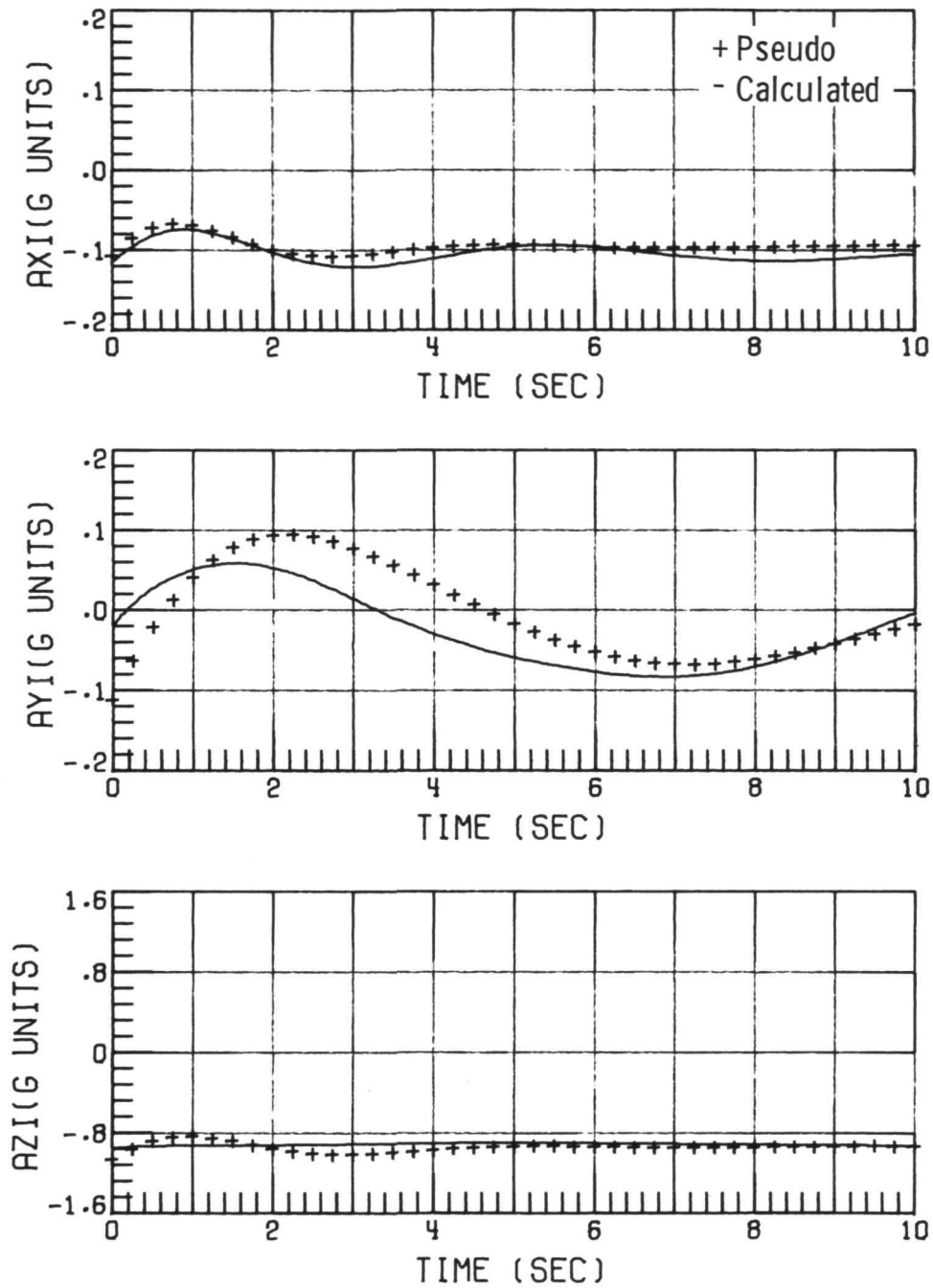
(a) Longitudinal motion.

Figure 4.- CalComp plot of pseudo and calculated (nonconverged solution) motion.



(b) Lateral motion.

Figure 4.- Continued.



(c) Accelerometer.

Figure 4.- Concluded.

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—NATIONAL AERONAUTICS AND SPACE ACT OF 1958

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